REPORT RESUMES

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FERTILIZERS SALES AND SERVICE. AGRICULTURAL SUPPLY - SALES AND SERVICE OCCUPATIONS, MODULE NUMBER 9.

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THE PURPOSE OF THIS GUIDE IS TO ASSIST TEACHERS IN PREPARING HIGH SCHOOL AND POST-HIGH SCHOOL STUDENTS FOR AGRICULTURAL SUPPLY OCCUPATIONS. ONE OF A SERIES, THIS MODULE WAS DEVELOPED ON THE BASIS OF STATE STUDIES BY A NATIONAL TASK FORCE. THE SPECIFIC OBJECTIVE IS TO PREPARE STUDENTS FOR ENTRY AND ADVANCEMENT IN FERTILIZER SALES AND SERVICE. SECTIONS ARE (1) ECONOMICS OF FERTILIZER USE, (2) PLANT NUTRITION, (3) SOIL PROPERTIES, (4) FERTILIZER CHARACTERISTICS, (5) FERTILIZER FORMULA INTERPRETATION, (6) SOIL SAMPLING AND FERTILITY NEEDS, (7) SOIL TEST INTERPRETATION, (8) FERTILIZER RECOMMENDATIONS, (9) FERTILIZER MANUFACTURING PRINCIPLES, (10) CUSTOMER SERVICE, (11) FERTILIZER MERCHANDISING, AND (12) FERTILIZER INDUSTRY TRENDS. INTRODUCTION AND EVALUATION TECHNIQUES AND SOURCES OF INSTRUCTIONAL MATERIALS ARE SUGGESTED. EACH SECTION INCLUDES SUBJECT MATTER CONTENT, TEACHING-LEARNING ACTIVITIES, INSTRUCTIONAL AIDS, AND REFERENCE SUGGESTIONS. TEACHERS SHOULD HAVE A BACKGROUND IN AGRICULTURAL SUPPLY AND STUDENTS SHOULD HAVE AN OCCUPATIONAL GOAL IN THE FIELD. THE MODULE IS DESIGNED FOR 24 HOURS OF CLASS INSTRUCTION, 26 HOURS OF LABORATORY EXPERIENCE, AND 50 HOURS OF OCCUPATIONAL EXPERIENCE. THIS DOCUMENT IS AVAILABLE FOR A LIMITED PERIOD AS PART OF A SET (VT 000 632 - 000 644) FOR $7.00 FROM THE CENTER FOR VOCATIONAL AND TECHNICAL EDUCATION, THE OHIO STATE UNIVERSITY, 980 KINNEAR ROAD, COLUMBUS, OHIO 43212. (JM)

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FERTILIZERS
SALES AND SERVICE

One of Twelve Modules in the Course Preparing for Entry in

AGRICULTURAL SUPPLY - SALES AND SERVICE OCCUPATIONS

Module No. 9

The Center for Research and Leadership Development
in Vocational and Technical Education

The Ohio State University
980 Kinnear Road
Columbus, Ohio, 43212

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August, 1965

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MEMORANDUM

TO: The ERIC Clearinghouse on Vocational and Technical Education
The Ohio State University
980 Kinnear Road
Columbus, Ohio 43212

FROM: (Person) James W. Hensel (Agency) The Center for Vocational and Technical Education

(Address) 980 Kinnear Road, Columbus, Ohio 43212

DATE: August 7, 1967

RE: (Author, Title, Publisher, Date) Module No. 9, "Fertilizers - Sales and Service," The Center for Vocational and Technical Education, August, 1965.

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(3) Utilization of Material:
Appropriate School Setting High school
Type of Program General high school class in agricultural supply
Occupational Focus Job entry in retail business that sell agricultural supplies
Geographic Adaptability Nationwide
Uses of Material Instructor course planning
Users of Material Teachers

(4) Requirements for Using Material:
Teacher Competency Background in agricultural supply--sales and services
Student Selection Criteria High school level, goal in agricultural supply--in the area of sales or service.
Time Allotment Estimated time listed in module. (P)

Supplemental Media --
Necessary x
Desirable
(Check Which)

Describe Suggested references given in module. (P)

Source (agency)
(address)

FERTILIZER - SALES AND SERVICE

Major Teaching Objective for a High School Course

To develop the understandings and abilities needed for initial employment as an "inside salesman" in the agricultural supply business, which includes fertilizer among its sales and services.

Major Teaching Objective for a Post-High School Course

To develop the understandings and abilities needed for entry and advancement in the agricultural supply business, which includes fertilizer among its sales and services.

Suggested Time Allotments

At school		
Class instruction	24 hours	
Laboratory experience	26 hours	
Total at school		50 hours
Occupational experience		50 hours
Total for module		100 hours

Suggestions for Introducing the Module

This module is applicable to two types of courses, the two-year high school course preparing students upon graduation for entry in the agricultural supply business which handles fertilizer along with its other products, and the post-high school course preparing older, more mature students for entry and advancement in the same business.

The levels of competence expected of the graduates of the two courses are different, however. At the high school level, this module is designed to help the person entering agricultural supply--sales and service occupations understand and use readily available information to assist customers in making their own decisions. As a result, the competencies to be developed are primarily at the understanding and appreciation levels, not those affected by age, maturity, or necessity for detailed technical preparation.

At the post-high school level, average students will be in a position to develop the effective abilities a salesman needs; for example, to interpret a soil test report, to determine basic fertility needs of soils, to make accurate fertilizer recommendations, and to understand the basic principles of fertilizer manufacture and plant operations.

In either case, the purpose of this module is to provide the student with the general background needed for sales and service in an agricultural supply business. It is not the purpose of this module to develop a technically trained fieldman who can make recommendations on complex fertilization problems involving environmental factors. A whole course in agricultural chemical technology is needed for such preparation.

When introducing the module, develop with the students a list of the local business firms which handle fertilizer materials for retail sale. This list should be complete enough to show both the types of fertilizer available as well as the service functions pertaining to fertilizers that are performed by them.

1. To sell fertilizer
2. To deliver fertilizer
3. To spread or apply fertilizer
4. To formulate, mix, and manufacture fertilizer
5. To advise customers on their fertilizer programs and problems

Display samples of the various types of fertilizer materials that are available to farmers and homeowners. Fertilizers come in the following forms:

1. Solid, liquid, and gaseous forms
2. Single element, mixed, and complete types
3. Chemical, organic

Create interest in problems to be considered by holding up a sample or two and asking the class such questions as:

1. Where would you recommend using this?
2. How much would you tell a farmer to put on his crop?
3. Which one is the best for the housewife's roses?
4. Which one will provide the greatest value at the lowest cost?

Ask the students why the fertilizer industry is so important. Point out that twenty percent of the agricultural production in the United States--equal to all the crop production in the States of Iowa, New Jersey, Connecticut, Massachusetts, and Delaware--is credited to the use of fertilizer. The cost of cultivating this much land would be more than three times the annual expenditure for fertilizer. Without fertilizer, this would be a nation of food scarcity instead of a land of plenty. This abundant crop production permits us to feed a livestock industry that provides the milk, meat, and eggs which supplies the American people a luxury diet second to none. To maintain this enviable position, however, crop production must keep pace with the exploding population. This means that the fertilizer industry needs to expand to supply the necessary plant food. The fertilizer industry has quadrupled its production in the past twenty-five years (1940-1965) and is expected to double it again by 1985 at an increase of five percent a year.

Since the future in the fertilizer industry is promising, so also is that in retail service and sales of fertilizer. How does a young man enter this area of employment? List with the students those understandings, abilities, and skills needed by employees in businesses selling fertilizers.

1. To appreciate the economic value of fertilizer in crop production
2. To understand how plant growth is related to the availability of plant nutrients and other environmental conditions
3. To understand how fertilization is affected by the basic physical, chemical, and biological properties of soil
4. To understand the characteristics of commonly used fertilizer materials
5. To interpret fertilizer formulas
6. To understand the methods used to determine the fertility needs of soils and to develop the ability to take soil samples
7. To interpret a soil test report
8. To make fertilizer recommendations
9. To understand the basic principles of fertilizer manufacture and plant operations
10. To understand how to advise customers about the selection, calibration, and maintenance of fertilizer equipment

11. To merchandise fertilizer effectively

12. To understand the importance of the fertilizer industry and its future trends

To be an effective employee at any level of employment in businesses handling fertilizers, one must have a working knowledge of these understandings and abilities. A young man's chances for employment in fertilizer sales and services and his opportunity for advancement are based on his ability to sell fertilizer. Customers buy primarily because they want such benefits as higher yields, reduced costs, saved labor, and early maturity. The sales employee needs to appeal to the basic needs of prospective customers in order to show how the use of fertilizers will be beneficial. Proper sales and service insures satisfied customers, increases the sales volume of the retail fertilizer outlet, and should result in advancement for the employee.

A test given at the beginning of this module could achieve two purposes: giving the instructor an indication of the students' level of understanding in this area, and motivating the students by showing them what they do not know.

Competencies to be Developed

I. To appreciate the economic value of the use of fertilizer in crop production

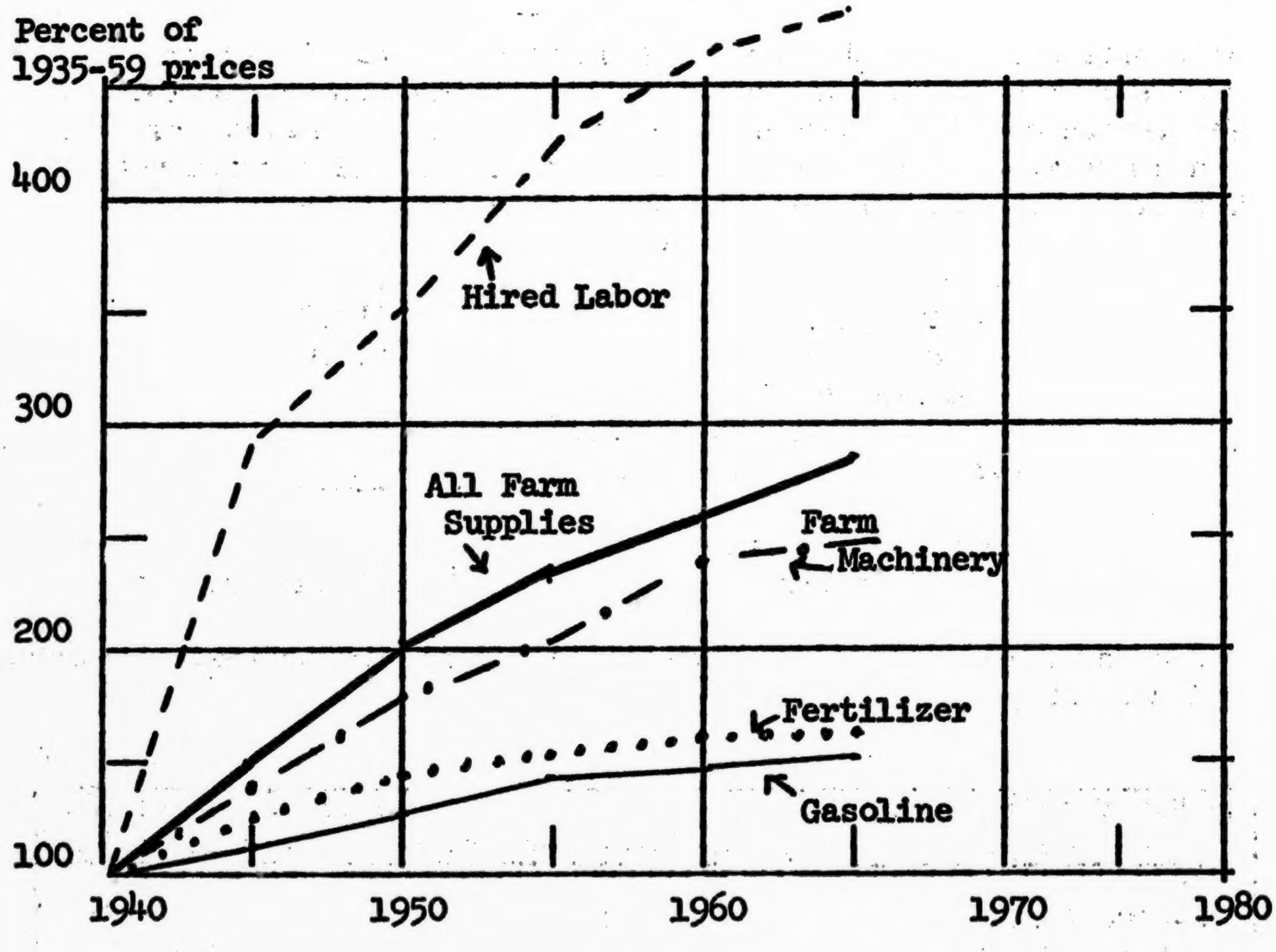
Teacher Preparation

Subject Matter Content

Fertilizer is one of the best buys of all the agricultural supplies a farmer or rancher needs. Whereas prices of all agricultural supplies have risen over 125 percent, commercial fertilizer prices have increased only about 15 percent in the past twenty-five years. This is shown on the chart on page 5.

Farmers and homeowners now are more aware of the economic value of fertilizer. The fertilizer industry, state land-grant colleges, and the U. S. Department of Agriculture have made considerable progress in educating the buyer in the proper use of fertilizer and its value in crop, lawn, and garden production. There is a growing realization that the proper use of fertilizers is of crucial importance in an era of narrow farm income production ratios.

PRICES PAID BY FARMERS



Source: USDA, Washington, D. C.

The economics of crop production should indicate the value of proper fertilization, but students should first understand fixed costs and variable costs. Fixed costs are those that cannot be reduced or eliminated. The yearly cost of land ownership or rental is always a fixed cost, unless the operator disposes of the land. Other costs are variable until the operation or purchase is made, then they become fixed. An example of a variable cost is plowing. Money can be spent to plow or not spent to plow; but, after plowing, the expense is fixed and must be paid, whether or not a crop is planted.

All costs listed in the example below are fixed. These are realistic figures taken from field trials with corn in Ohio. The teacher could develop more appropriate examples from his own state to make the point more pertinent to the students. The fixed costs of growing an acre of corn were:

Land	$ 9.50
Machinery	12.00
Labor	14.00
Supplies (seed, weed spray, and others)	8.00
Miscellaneous costs	1.50
Total costs, except for fertilizer	$45.00 an acre

Three levels of fertilizer were applied with the following costs and results.

Level of application per acre	Cost of fertilizer	Bushels of corn per acre
Low--100 lbs.	$ 4.00	45.0
Average--228 lbs.	$ 9.12	51.3
Recommended--700 lbs.	$28.00	76.5

The economic results are apparent in the following tables. Note that at $1.00 per bushel, fertilizer levels below the recommended level result in a net loss.

Level of application per acre	Total costs, fixed plus fertilizer	Value of corn at $1.00	$1.15	$1.30
Low	$49.00	$45.00	$51.75	$58.50
Average	$54.12	$51.30	$59.00	$66.69
Recommended	$73.00	$76.50	$87.98	$99.45

Level of application per acre	Profit or loss per acre $1.00	$1.15	$1.30
Low	- $4.00	$2.75	$9.50
Average	- $2.82	$4.88	$12.57
Recommended	$3.50	$14.98	$26.45

Three factors relate to the provit from growing a crop.

1. The total costs of production
2. The level of production (bushels of corn)
3. The market value of the product (corn)

The recommended level of fertilization can best be determined by accurate soil fertility tests and carefully controlled test plots conducted in the farmer's fields. Developing an understanding of how these procedures are used is the subject of Competency No. VI.

Limited capital frequently prevents the application of fertilizer at recommended levels. Research shows that return per dollar invested in fertilizer is higher at low fertilization than at high, but high fertilization brings the greatest total return per acre per dollar spent.

Nationwide studies show that crop producers are using less than forty percent of the recommended levels of fertilizer. This is an indication of the sales potential at the retail level and the service that can be provided to crop producers to enable them to increase their production and profit.

Suggested Teaching-Learning Activities

1. Have students study their community and locate the concerns that handle fertilizers to determine the types and volume handled.
2. Help students determine how much crop production must increase by the year 2000 to feed our expected population.
3. Have each student interview a farmer to determine the amount of fertilizer used per acre and his expected use of fertilizer in the future.

4. Develop with the students comparisons of yields and production costs for local crops.

5. Review state college of agriculture publications showing the results of fertilization demonstrations.

6. Take a field trip to a local fertilization demonstration plot.

7. Invite a resource person from a local fertilizer distributorship to discuss with the class actual examples of crop production economics based on cases in the community.

Suggested Instructional Materials and References

Instructional Materials

1. Data collected on the results of local fertilization demonstrations
2. Slides or films, such as Profit in Forage and Pasture, showing crop yield response to fertilization.

References

1. Our Land and Its Care, pp. 63-67.
2. The Fertilizer Handbook, pp. 133-198.
3. Using Commercial Fertilizers, pp. 237-249.

Suggested Occupational Experience

Have students develop in cooperation with their employers, or as a class project, a fertilizer test demonstration to show the economics of crop production.

II. To understand how plant growth is related to the availability of plant nutrients and other environmental conditions

Teacher Preparation

Subject Matter Content

Before one can understand plant responses, one should review the life processes of plants. Students should have been exposed to these principles in earlier agriculture or biology classes.

1. Photosynthesis: combining of carbon dioxide and water to make sugar by a plant
2. Transpiration: the movement of water through a plant and out into the air
3. Respiration: combination of sugars and oxygen to provide energy, carbon dioxide, and water
4. Assimilation: changing of simple sugars into the more complex carbohydrates, fats, and proteins
5. Growth and reproduction: the results of photosynthesis, transpiration, respiration, and assimilation, which results in the desired crop or plant production

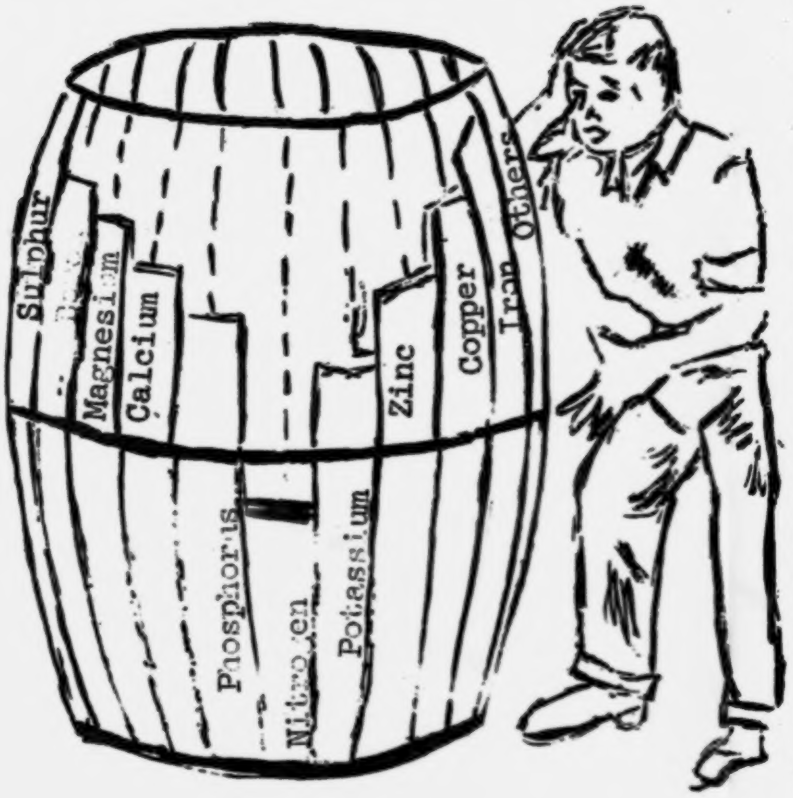
Students interested in employment in sales and service involving fertilizer materials should concern themselves mainly with how plants use fertilizer, but they must also be aware of the effects of other environmental conditions on the growth and reproduction of plants.

Sixteen nutrients must be supplied for plant life. The sources of these essential nutrients are air for carbon, oxygen, and nitrogen in the case of legumes; water for hydrogen and oxygen; and soil for all other needed nutrients. Under most growing conditions, water and air provide adequate amounts of hydrogen, oxygen, and carbon; but the remaining thirteen essential plant nutrients must be supplied by the soil. One or more of these is present in limited amounts in most soils. The fertilizer dealer should assist the customer in determining which nutrients are lacking and then supply them for the farmer or homeowner.

Students should realize that all crops require the same soil nutrients, but in varying amounts. Some examples are given in the table below. See The Fertilizer Handbook, pp. 54-55, for a complete list of crops and their nutrient requirements.

THIS BARREL WILL HOLD NO MORE THAN THE LEVEL OF THE LOWEST STAVE. LIKEWISE, THE YIELD OF A CROP CAN BE NO HIGHER THAN THE LEVEL OF THE LOWEST PLANT NUTRIENT.

FREQUENTLY, NITROGEN IS THE NUTRIENT WHICH IS AT THE LOWEST LEVEL.....AND THEREFORE, LIMITS THE LEVEL OF PRODUCTION AS IN THE ILLUSTRATION AT RIGHT. ADDING NITROGEN WILL INCREASE THE YIELD IN THIS CASE UNTIL POTASSIUM BECOMES THE LIMITING FACTOR AND SO ON UP THE BARREL.



Students should realize that all crops require the same soil nutrients, but in varying amounts. Some examples are given in the table below. See The Fertilizer Handbook, pp. 54-55, for a complete list of crops and their nutrient requirements.

Pounds of Nutrients Required Per Acre by Major Crops

Crop	Yield/A	Nitrogen	Phosphorus	Potassium
Corn	100 bu.	90	36	26
Oats	80 bu.	50	20	15
Wheat	40 bu.	50	25	15
Alfalfa	4 ton	180	40	180
Soybeans	40 bu.	150	35	55
Cotton	1,500 lbs.	40	20	15
Tomatoes	20 ton	120	40	160
Sugar Beets	20 ton	80	27	66

Primary, secondary, and micro or trace elements are the three recognized classes of essential soil elements. Following is a brief discussion of their functions in plant growth.

1. Primary plant nutrients (N, P, K) are called primary because soils normally cannot provide them in the large amounts needed for healthy growth.

a. Nitrogen (N)

  1) Gives dark green color to plants
  2) Promotes rapid growth
  3) Improves quality and protein content

b. Phosphorus (P) is expressed in fertilizer as available phosphate (P_2O_5).

  1) Stimulates early root development and growth
  2) Hastens maturity, promotes seed production
  3) Improves winter hardiness of legumes

c. Potassium (K) is stated in terms of potash (K_2O).

  1) Increases vigor and disease resistance
  2) Aids in food formation
  3) Stiffens straw and stalk parts

2. Secondary plant nutrients (Ca, Mg, S), are required by plants in substantial quantities. Soils are adequate in some areas and lacking in others.

a. Calcium (Ca)

  1) Promotes early root formation and growth
  2) Encourages seed production
  3) Neutralizes poisons produced in plants

b. Magnesium (Mg)

  1) Maintains chlorophyll and photosynthesis
  2) Forms sugar, fats, and oils
  3) Plays a part in translocating food within the plant

c. Sulfur (S)

  1) Is essential ingredient in protein
  2) Maintains dark green color
  3) Promotes module formation on legumes

3. Micro-nutrients (B, Cu, Fe, Mn, Mo, Zn, Cl) are required by plants in trace amounts. Sandy soils, peats, and mucks are most often deficient in them.

- a. Boron (B)
    - 1) Increases yield and quality
    - 2) Is associated with calcium utilization
- b. Copper (Cu)
    - Important in citrus and vegetable production
- c. Iron (Fe)
    - 1) Is associated with formation of chlorophyll
    - 2) Aids in plant respiration
- d. Manganese (Mn)
    - 1) Accelerates germination and maturity
    - 2) Aids in photosynthesis
- e. Molybdenum (Mo)
    - Is used by legumes in nitrogen fixation
- f. Zinc (Zn)
    - 1) Is necessary for chlorophyll formation
    - 2) Is vital as a growth regulator
- g. Chlorine (Cl)
    - Functions not understood

Escessive amounts of minor nutrients can be as harmful as inadequate amounts. Micro-nutrients are usually deficient in the following types of soil:

- 1. Muck and peat soils
    - a. Boron
    - b. Copper
- 2. Alkaline soils
    - a. Iron
    - b. Manganese
    - c. Zinc

3. Acid soils

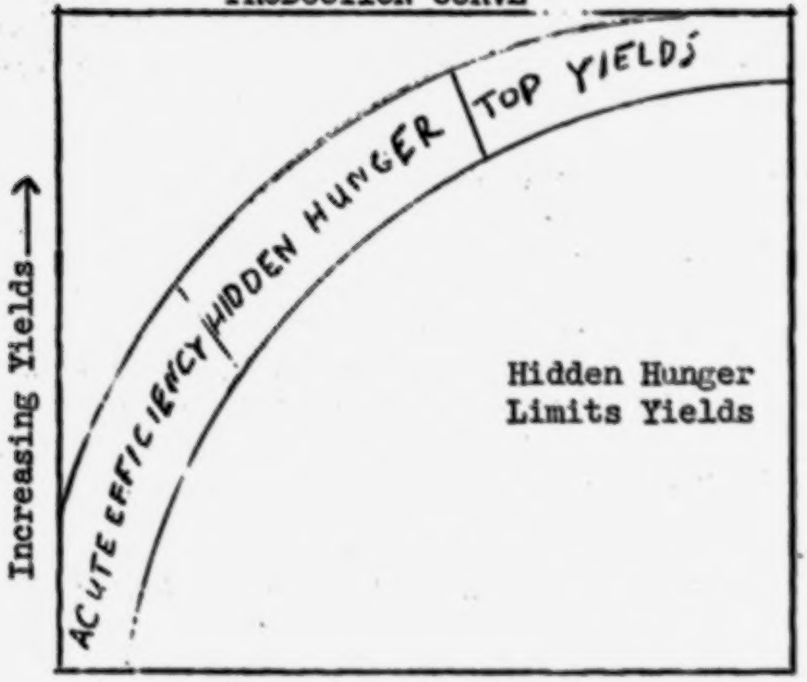
   Molybdenum

Acute deficiencies of nutrients reveal themselves in visual changes in color and structure of the plant or plant parts. Students should become acquainted with the common hunger symptoms of plants in their area by comparing actual plants or plant parts with color photos or drawings of healthy and deficient plants. Caution should be taken in positive identification because

1. It is difficult to distinguish among symptoms when more than one nutrient is lacking.
2. Damage from disease and insects and other factors may mask or resemble certain deficiency symptoms.

"Hidden hunger" of crops is more widespread and is much more of an economic problem than are acute nutrient deficiencies because it limits yields and affects quality. Farmers are unaware of its damage since it cannot be seen. Hidden hunger cannot be corrected in the current crop, but with appropriate means can be largely eliminated in succeeding crops.

PRODUCTION CURVE



Factors other than elements in the soil can affect crop response. Environmental conditions, such as moisture, disease, insects, weeds, light, soil conditions, and temperature, can influence crop quality and production.

1. Effects of water
    a. The rate of plant growth is related to the amount of available water. Crops vary in the amounts of water needed to produce high yields.
    b. Crops grown on fertile soil make better use of the available water supply.
    c. High temperature, low humidity, and wind increase water requirements of plants.
    d. Proper tillage and weed control conserve water for crops.
2. Effects of light
    a. Plants have varying requirements for day length.
        1) Peas, asters, and others prefer short days.
        2) Clover, corn, beets, and others prefer long days.
    b. Intensity or amount of light received
        1) Plant spacing and the trend to narrower corn and soybean rows make better use of light.
        2) Density of companion crops with legumes
        3) Weed control in young crops is necessary for provision of adequate light.
3. Effects of temperature
    a. Excessive cold
        1) Winterkilling, dehydration
        2) Late frost damage to buds and flowers
        3) Early frost damage to late maturing crops
    b. Excessive heat
        1) Wilting, dehydration
        2) Poor pollination and fertilization

4. Effects of soil conditions

    a. Poor soil aeration

        1) Increases toxicity of soils
        2) Impairs drainage
        3) Can be corrected by addition of organic matter

    b. Soil acidity

        1) Reduces availability of soil nutrients
        2) Increases toxicity of soil
        3) Can be corrected by liming

    c. Soil salinity or alkalinity

        1) Reduces availability of soil nutrients
        2) Is caused by low rainfall and high evaporating, poor drainage or poor irrigation practices
        3) Can be corrected by leaching of toxic materials from soil by irrigation
        4) Treatment of soils with residually acid fertilizers or acid-formers

5. Insects and diseases

    a. Prevent plants from absorbing nutrients

    b. Prevent plants from translocating nutrients

    c. Damage leaf area and reduce photosynthesis

    d. Remove sap and plant food from plant

6. Weeds

    Compete for plant food, water, and sunlight

Low crop yields can be caused by factors other than plant food and environmental conditions.

1. Improper plant population

2. Incorrect time and cultural methods

3. Use of low-quality seeds

Fertilizer alone cannot produce a 100 bushel corn crop, 20 tons of sugar beets, 6 tons of alfalfa, or 4 bales of cotton per acre. Proper cultural practices are needed along with proper fertilization. Before seeking employment in the retail fertilizer business, students need to understand the relationship of crop production to plant nutrients and other environmental conditions.

Suggested Teaching-Learning Activities

1. Set up demonstrations with plants to show the principles of photosynthesis, transpiration, and respiration. Most biology texts give procedures for these demonstrations.

2. Grow a common crop in sand-filled pots, one lacking nitrogen, one lacking phosphorus, and another lacking potash. See if typical deficiency symptoms appear. One control pot should supply all necessary nutrients.

3. Collect samples of specimens or colored slides of plant deficiency symptoms for class display.

4. Show the film Making the Most of a Miracle, which tells the story of basic plant nutrition.

5. Arrange a field trip so that students may observe several conditions that might limit crop response. Have them attempt to identify the unfavorable conditions limiting crop growth.

Suggested Instructional Materials and References

Instructional Materials

1. Pots, sand, fertilizers, seed, and water necessary to conduct the demonstrations

2. Samples of plant specimens showing nutrient deficiencies, disease, and insect damage

3. Film Making the Most of a Miracle

4. Sets of color slides of nutrient deficiency symptoms in plants (can be obtained from the National Plant Food Institute)

References

1. Be Your Own Corn Doctor.
2. Hunger Signs in Crops.
3. Our Land and Its Care, pp. 22-39.
4. Profitable Soil Management, pp. 99-122.
5. The Fertilizer Handbook, pp. 39-57.
6. Using Commercial Fertilizers, pp. 1-5.

Suggested Occupational Experience

The student should visit farms with fertilizer field men to view crops and assist in determining the conditions that might be reducing crop response.

III. To understand how fertilization is affected by basic physical, chemical, and biological properties of soils

Teacher Preparation

Subject Matter Content

A complex interrelationship existing between the physical, chemical, and biological characteristics of soil influences fertilization and crop response. Before effective sales and service can be performed by employees of the retail fertilizer business, problems concerning soil and water relationships must be understood.

Certain physical characteristics create problems in the use of commercial fertilizers.

1. Texture of the soil
    a. Leaching is a problem in coarse, textured soils, or in soils affected by excessive rainfall or irrigation. Plant food moves down and out of the root zone.
    b. Heavy textured soils may be waterlogged, cold, and slow in releasing nitrogen for plant growth.

   c. Texture of soil can be improved by addition of organic matter.

   d. Soil drainage causes soils to warm up.

2. Structure of the soil

   a. Compacted soils are likely to be wet and cold and lacking in air, as well as slow in releasing nitrogen.

   b. Structure of the soil can be improved by the addition of organic material.

3. Plant nutrients available to the soil

   a. Nitrogen per acre of plow layer

      1) Total of 1,400 to 7,500 pounds
      2) About 2% available, 28-150 pounds
      3) Nitrogen is contained only in the organic portion of the soil

   b. Phosphorus per acre of plow layer

      1) Total of 9,000 pounds
      2) About 1% available, 0-90 pounds
      3) Contained in organic and mineral portions of the soil
      4) Clays are high in phosphorus, may be unavailable

   c. Potassium per acre of plow layer

      1) Large amounts, 30,000 pounds
      2) About $\frac{1}{4}$-$\frac{1}{2}$% available, 75-150 pounds
      3) Contained in mineral and organic portions

   d. Soils high in sand and low in organic matter have low natural fertility.

4. Temperature of soil

   a. Low temperatures retard the decomposition of organic matter and cause nutrients to be released slowly.

   b. Warm soils, year around, hasten decomposition and cause possible leaching of nutrients.

5. Water content of the soil
    a. Saturated soils reduce bacterial action and organic matter decomposition.
    b. Excessive percolation causes leaching.
    c. Contrary to certain opinions, high fertility with lack of water will not "burn" crops. Crops make better use of water when fertility is high.
6. Organic matter content of soils
    a. Contains all the nitrogen and large percentages of the phosphorus and potassium available for plant growth
    b. Improves the tilth of the soil
    c. Improves the water holding capacity of the soil

Biological conditions within the soil can affect the results obtained from fertilizer. The types of living things in soil are

1. Microorganisms found in the soil
    a. Bacteria--make nitrogen available
    b. Actinomycetes--digest cellulose
    c. Fungi--decompose organic matter
    d. Algae--add organic matter to soil and improve structure
    e. Protozoa--active in moist soils
2. Higher forms of animal life in the soil
    a. Slugs and snails
    b. Arthropods, such as ants, mites, springs tails
    c. Nematodes--both helpful and harmful
    d. Earthworms--aerate soil and improve structure

3. Higher forms of plant life

    a. Roots

        1) Improve structure
        2) Aerate the soil
        3) Add organic matter

4. Effects on crop response

    a. Break down organic matter into plant nutrients

    b. Changing of minerals from insoluble to soluble form by acids formed by microorganisms

    c. Change free nitrogen into plant nitrogen

        1) Symbiotic, with legumes
        2) Non-symbiotic, free living

    d. Improve soil tilth

5. Factors affecting action of soil organisms

    a. Food must be in balance. When nitrogen is lacking, organisms decompose cellulose, such as in corn stalks and wheat straw, slowly. Organisms may "tie up" available nitrogen and cause a temporary nitrogen depletion.

    b. Temperature must be favorable for soil organisms to be active enough to release plant food.

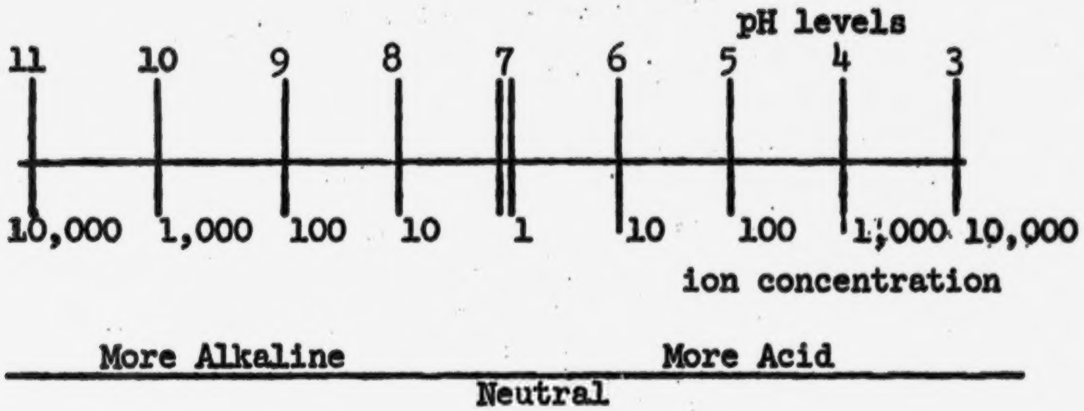
    c. Moisture range is wide, but activity is low in dry or saturated soils.

    d. Acidity must be present because nitrogen-fixing bacteria require a range of 6.0 - 8.0 pH.

    e. Air is necessary, since most soil organisms are aerobic and thus inactive in compact or saturated soils.

Chemical properties of a soil affect the response of crops to the application of fertilizer. Our primary concern is the relative number of hydrogen and hydroxyl ions, expressed as pH, of the soil present.

1. The soil reaction


pH levels
11
10
9
8
7
6
5
4
3
10,000
1,000
100
10
1
10
100
1,000
10,000
ion concentration
More Alkaline
More Acid
Neutral

   a. pH 7 is a neutral soil containing equal numbers of free hydrogen and hydroxyl ions.

   b.. pH below 7 is acid and contains more free hydrogen ions.

   c. pH above 7 is alkaline and contains more free hydroxyl ions.

   d. pH of 9 is 10 times more alkaline than a pH of 8 and 100 times more so than a pH of 7.

2. Effects of pH on plant nutrient availability

   a. See graph "How Soil pH Affects Availability of Plant Nutrients," page 20, of The Fertilizer Handbook.

   b. Primary and secondary nutrients become less available below a pH of 6.5.

   c. Nitrogen, phosphorus, and several trace nutrients become less available over a pH of 7.5.

   d. The best availability of nutrients is in the range of 6.5 to 7.0 pH.

3. Soil reaction favored by selected crops

   a. See the table, page 19, of Our Land and Its Care, for the pH requirements of many crops and ornamentals.

   b. In general, crops favor a pH that is slightly acid.

   c. Extremely high pH is as bad as extremely low pH.

4. Correcting acidic conditions when necessary

   a. Determine pH with soil test

   b. Types of liming materials

      1) Ground limestone (Ca) or dolomitic limestone (Ca + Mg) most common
      2) Burned or hydrated lime
      3) Oyster shell meal
      4) Marl
      5) Blast furnace slag

   c. Criteria for determining kind of material to use

      1) Availability and cost
      2) Use for which it is intended; burned lime corrects reaction rapidly; dolomitic limestone adds magnesium
      3) Total neutralizing power of material

Common Liming Materials

Name	Analysis	Neutralizing Power
Lime	$CaCO_3$	100
Ground Limestone	80-95% $CaCO_3$	85-100
Ground Dolomitic Limestone	52% $CaCO_3$ 42% $MgCO_3$	95-108
Hydrated Lime	65% CaO	120-135
Marl	60% $CaCO_3$	50-90

      4) Fineness of the liming material

Particle Size	Efficiency Rating (Percent)
Material passes a 60 mesh sieve	100
Material passes a 20, not a 60, mesh sieve	60
Material passes an 8, not a 20, mesh sieve	20

Liming materials must be finely ground to avoid reacting too slowly with the soil to be effective.

d. Amount of liming material to use

1) Varies by material used
2) Varies by type of soil
3) Varies by organic matter content of soil

Approximate Amounts of Different Liming Materials Required to Raise the pH Value One Unit on Various Soils.

Soil	Ground Limestone or marl lbs. per acre	Hydrated Lime lbs. per acre
Light sands	1,500	1,100
Sandy loams	2,000	1,480
Loams	3,000	2,220
Silt and clay loams	3,500	2,590

For soils low in organic matter, reduce the above amounts by 25 percent. For soils high in organic matter, increase these amounts by 100 percent.

e. Values of liming

1) Corrects soil acidity
2) Supplies calcium and magnesium
3) Speeds decay of organic matter and liberation of plant food
4) Increases availability of phosphate
5) Increases fixation of nitrogen
6) Improves crop yields
7) Improves physical properties of soil
8) Reduces toxic substances in the soil

5. Correcting saline and alkaline soils when typical of local conditions

a. Production problems

1) Serious in arid and semi-arid areas
2) Problem on 7 million irrigated acres and extensive non-irrigated acres in U. S.

b. Salinity, alkalinity, and pH

    1) Alkalinity refers to soils with a pH in excess of 7.0.
    2) Saline soils are high in soluble salts.
    3) Alkaline soils are likely to be high in soluble sodium salts.

c. Saline soils

    1) Excessive soluble salts results from:

        a) Low rainfall and high evaporation
        b) Inadequate drainage
        c) Poor irrigation practices
        d) Use of poor quality irrigation water

    2) pH of 7.0 to 8.5; few sodium salts
    3) Measured by chemical or electrical conductivity tests
    4) Reduce water absorption by roots
    5) Have toxic effect on plants
    6) Require high quality irrigation water
    7) Planted with salt tolerant crops

d. Alkaline soils

    1) Possible range of pH from acidic to pH of 8.5 or more
    2) May be high in exchangeable sodium ions
    3) Have poor tilth, swell when wet, shrink, crack, and become compact when dry

e. Correction of alkaline soils

    1) Determine by a soil test the amount of exchangeable sodium
    2) Determine the kind and amount of soil amendment to use, based on soil characteristics, desired rate of replacement, and economics

Types of Amendments

Soluble calcium salts:
- Calcium chloride
- Calcium sulfate (gypsum)

Calcium salts of low solubility:
- Calcium carbonate (limestone)

Acids or acid-formers:
- Sulfuric acid
- Sulfur
- Lime-sulfur
- Iron sulfate
- Aluminum sulfate
- Ammonium sulfate
- Ammonium polysulfide
- Ammonium thiosulfate
- Ammonium nitrate
- Sulfur dioxide

Sulfur Equivalents of Various Soil Amendments

Amendment	Tons to Equal One Ton of Sulfur
Sulfur	1.00
Sulfur dioxide	2.00
Sulfuric acid	3.06
Gypsum	5.38
Iron sulfate	8.96
Aluminum sulfate	6.94

a) In general, to correct every three milliequivalents per 100 grams of exchangeable sodium requires one ton of sulfur or five tons of gypsum.
b) One acre foot of irrigation water will dissolve one ton of high grade gypsum.
c) Acids and acid formers lower the pH.
d) One pound of sulfur requires three pounds of calcium carbonate to maintain the same pH.
e) Sulfur and gypsum generally are the most economical amendments.
f) Soil structure can be improved by crop growth, adding organic matter, alternate wetting and drying, and freezing and thawing.

Only after the physical, chemical, and biological conditions of the soil are properly corrected and controlled can the full effectiveness of a fertility program be achieved. Indeed, on many soils using fertilizer would be futile unless all soil conditions were balanced for proper plant growth. However, an employee should be capable of educating customers on improving soil conditions and crop response with fertilizer.

1. Fertilizer enables plants to make more effective use of available water.
2. Fertilizer encourages microorganism activity in the soil.
3. Fertilizer improves the structure and tilth of a soil.
4. Fertilizer (calcium, magnesium, sulfur) improves the soil reaction.
5. Fertilizer provides plants with the needed nutrients.

Suggested Teaching-Learning Activities

1. Demonstrate how soil texture and structure can affect water movement and influence plant growth and fertilizer usage by leaching. Demonstrate the leaching of nitrates through sandy soil and explain its implication to crop production.
2. Demonstrate how aeration, water, and temperature can influence decomposition of organic matter.
3. Plan a field trip to show students local soil problems that can influence crop response to fertilizer usage.
4. With demonstrations, show the effect acidity and/or alkalinity can have on the response of local crops. Barley seeds planted in quart jars containing the same loam soil but with different artificially introduced pH ranges from pH 5 to pH 10 will vividly illustrate this.
5. Have students collect, identify, and become familiar with the available amendments used for acid, alkaline, or saline conditions, their values and their costs.
6. Plan a field trip to an industry that manufactures or processes materials for correction of pH or alkaline conditions.
7. Show colored slides (64) Soils, Plant Nutrition and Fertilizer.

Suggested Instructional Materials and References

Instructional Materials

1. Obtain for demonstrations samples of soil showing structure, texture, and other qualities. Collect samples of materials used to correct soil reaction.
2. Display posters, "Lime Means More Money for You," and "How Soil pH Affects Plant Food Availability."
3. Slides, Soils, Plant Nutrition and Fertilizer

References

1. Our Land and Its Care, pp. 16-19.
2. Profitable Soil Management, pp. 33-82; 123-158.
3. The Fertilizer Handbook, pp. 13-38.

Suggested Occupational Experience

Have each student participate with a salesman in several farm calls where farmers have difficult soil problems. Have him report on these visits. Indicate the problem(s) and recommendations given to the farmer. Have a capable student working with a training center cooperator assist a farmer with a test plot with a soil reaction problem. Have students make simple soil pH and primary element tests in the field.

IV. To understand the characteristics of commonly used fertilizer materials

Teacher Preparation

Subject Matter Content

Sales and service employees in the retail fertilizer business should be familiar with the various fertilizer materials and their characteristics that will or will not make them suited to the various needs of customers. The materials available for the three major plant foods--nitrogen, phosphorus, and potassium--should be studied.

Nitrogen is an abundant, inert gas found in the atmosphere. Before it can be used by most plants, it must be combined with oxygen or hydrogen.

1. Nitrates (NO_3): one atom of nitrogen plus three atoms of oxygen
2. Ammonia (NH_3): one atom of nitrogen plus three atoms of hydrogen

Three groups of nitrogen-carrying materials are used in the fertilizer industry.

1. Inorganic nitrogenous materials
   a. Sulfate of ammonia
   b. Anhydrous and liquid ammonia
   c. Nitrate of soda
   d. Ammonium nitrate
   e. Ammonium phosphate
   f. Calcium nitrate
   g. Nitric phosphates
   h. Nitrate of potash
2. Natural organic nitrogen materials
   a. Plant and animal by-products
   b. Guano
3. Synthetic organic nitrogen materials
   a. Urea
   b. Calcium cyanamid

The major nitrogen materials, their analyses, and 1961 production in tons are given in the following table. Use current figures as they become available. These figures present a picture of the vast amount of nitrogen materials used by the fertilizer industry.

Material	Percent Nitrogen	1961 Tonnage
Anhydrous ammonia	82	679,000
Ammonium nitrate	33.5	498,000
Nitrogen solutions	21-49	281,000
Ammonium sulfate	21	118,000
Ammonium phosphates	11-21	102,000
Aqua Ammonia	16-25	84,000
Sodium nitrate	16	66,000
Urea	46	90,000
All others		37,000
Total, separate materials		1,955,000
Nitrogen used in mixtures		1,048,000
Total, nitrogen fertilizers		3,003,000

The characteristics of the major nitrogen materials must be understood before intelligent sales and service can be made.

1. Anhydrous ammonia

    a. Toxic, hazardous gas, difficult to store and handle

        1) Can cause serious burns
        2) Can cause death by asphyxiation
        3) Is flammable and explosive
        4) Is stored in steel tanks with a strength of 265 pounds per square inch

    b. Anhydrous ammonia

        1) Is 99.5% ammonia, 81.8% nitrogen (82%)
        2) Is 5% water
        3) Weights 5.14 pounds at 60°F.

    c. Application

        1) Applied "into" soil at a depth of 4-8 inches, depending on soil conditions
        2) Develops its own pressure
        3) Rate of application controlled by valves
        4) Requires special handling and application equipment

d. Retention and behavior in soil

    1) Little or no loss under normal soil conditions
    2) Some losses in exceptionally sandy, dry, or wet and cloddy soils
    3) Retention of ammonia on clay and organic particles in the soil
    4) May make clay stiffer and more compact, but probably not enough to be significant
    5) Increases pH in zone of application; improves solubility of phosphate slightly
    6) Less leaching than with nitrates

2. Ammonium nitrate

    a. Solid chemical compound containing 33.5% nitrogen

        1) Water soluble, quick acting
        2) Approximately one-half of the available nitrogen in nitrate form and one-half in the ammonia form

    b. Has an affinity for moisture; will cake

        1) Has protective covering to decrease absorption of water
        2) Is stored in water-proof bags

    c. Safety precautions with ammonium nitrate

        1) Don't smoke or expose to open flames.
        2) Keep away from steam pipes, electrical wiring, and combustible materials.
        3) Store in well-ventilated buildings.
        4) Clean up and discard spilled material.
        5) Promptly destroy empty bags.

    d. Application with a dry fertilizer applicator, surface or subsurface

    e. Retention and behavior in soil

        1) Rapid solubility; rapid uptake by plants
        2) Possible leaching of nitrate portion in sandy soils
        3) Reduces pH slightly

3. Nitrogen solutions

   a. Nitrogen materials that dissolve in water

      1) Ammonium nitrate
      2) Urea
      3) Ammonia

   b. Low-pressure and non-pressure type

      1) Free ammonia in low pressure type
      2) Crystallization (salting out) problem in cool weather (See table)

Properties of Selected Liquid Nitrogen Fertilizers

Total Nitrogen Available in Solution	Composition of Liquid Fertilizer by Percent				Total Composition in Percent	Crystallization temperature (°F)
	Free Ammonia	Ammonium Nitrate	Urea	Water		
41.0%	22.2	65.0		12.8	100	21°
41.0	19.0	58.0	11.0	12.0	100	7°
32.0		44.3	25.4	20.3	100	32°
20.0		57.3		42.7	100	42°
20.0	24.3			75.7	100	-70°

   c. Storage and application

      1) Non-pressure--no special storage problems
      2) Low pressure--stored in sealed tank with pressure gauge
      3) Corrosive to steel; aluminum or fiber glass tanks recommended
      4) Possible application of non-pressure to soil surface
      5) Necessity of putting low pressure into the ground

4. Ammonium sulfate
    a. Dry material containing 21% nitrogen, 24% sulfur
    b. Does not absorb water or cake
    c. Leaves acid residue, lowering soil pH
    d. Should be applied to land in bands or broadcast, surface or subsurface
5. Ammonium phosphates
    a. Types
        1) Mono-ammonium phosphate containing 11 to 16% nitrogen
        2) Di-ammonium phosphate containing 16 to 21% nitrogen
    b. Dry material fertilizers, well suited for top dressing grasses and legumes
    c. Lowers the soil pH
6. Aqua ammonia
    a. 20-26% nitrogen, ammonia dissolved in water
    b. Similar to anhydrous ammonia; less hazardous
    c. Must be pumped, does not supply its own pressure
    d. Is applied two or more inches deep with special equipment
7. Sodium nitrate
    a. 16% nitrogen, mined or manufactured
    b. Dry material; applied in bands or broadcast; surface or subsurface
    c. Rapidly available; water soluble
    d. Slight increase in soil pH
    e. Absorbs water; should be stored in dry place in waterproof bags; will cake

    f. Should not be used on heavy clay soils possessing a high pH; may produce a "black alkali" condition

8. Calcium nitrate
    a. 16% nitrogen, dry material
    b. Absorbs water, should be stored in dry place in water-proof bags
    c. Slight increase in soil pH
9. Nitric phosphates
    a. 12-20% dry material
10. Natural organic nitrogen materials
    a. Largely insoluble in water, 2-9% nitrogen
    b. Nitrogen released slowly as organic matter decomposes
    c. Favored in some lawn fertilizers
    d. No danger of leaching
    e. Relatively high priced
11. Urea
    a. Dry material, containing 46% nitrogen
    b. Water soluble, favored for foliar spraying
    c. Urea combined with formaldehyde is slow releasing (urea-form)
12. Cyanamid
    a. Dry material, 21-22% nitrogen
    b. Water soluble

Most phosphorous fertilizers are processed products from vast rock phosphate resources mined largely from Florida, Tennessee, and the western mountain states. About two percent come from other sources, including bone meal, basic slag, and colloidal phosphate.

The major phosphorous fertilizers, their analyses, and 1961 tonnage are given in the following table.

Material	Percent Phosphoric Oxide	1961 Tonnage
Ammonium phosphates	20-53	188,000
Superphosphates	Over 22	202,000
Superphosphates	18-20	96,000
Phosphate rock	30-36*	24,000
All others		57,000
Total, separate materials		565,000
Phosphates used in mixtures		2,032,000
Total, phosphates all fertilizers		2,597,000

*The phosphorus in rock phosphate is largely insoluble on most soils.

Characteristics of the major phosphorous fertilizers and their uses must be understood. Most of the phosphorus in soils is in a comparatively insoluble form. Even soluble phosphates are often transformed into less soluble phosphates, called "fixed," in many soils. The type of phosphorus to use and method of application are important factors to consider. In general, more phosphorous fertilizer should be added than is required by the growing crop. However, this additional phosphorus is held in the soil for succeeding crops.

1. Rock phosphate
    - a. Relatively insoluble; slowly available to crops
    - b. Can raise the phosphorous level in soil
    - c. Effectiveness improved by fine grinding
    - d. Best results on acid soils high in organic matter
2. Superphosphate
    - a. Most widely used source of phosphorus
    - b. Does not change pH of soil

c. Phosphorus is soluble in soils

d. Two types of superphosphate

1) Single strength, 18-20 percent phosphoric oxide
2) Triple superphosphate, 40-50 percent phosphoric oxide; often called double, treble, or concentrated superphosphate

3. Ammonium phosphates

a. Contain nitrogen and 15-53 percent phosphate

b. Phosphorus nearly all water soluble

c. Commonly used in complete fertilizers

d. Common types

1) Mono-ammonium phosphate--48%, trade name Ammo-phos A
2) Di-ammonium phosphate--48-53%, trade name Ammo-phos B
3) Ammoniated superphosphate--18-20%
4) Ammonium phosphate-nitrate--15%
5) Ammonium phosphate sulfate--20-39%

4. Nitric phosphates

a. Contain nitrogen plus 10-22 percent phosphate

b. Relatively new material; increase in use

5. Liquid phosphoric acid

a. As indicated, a liquid, 52-54% phosphate

b. Used in irrigation water or directly sprayed on soil

c. Lowers pH on alkaline soils

d. Superphosphoric acid, 75% phosphate

e. More costly than other recommended phosphorous fertilizers

f. Strong acid, should be handled with care

6. Colloidal phosphate
    a. Trade mark for a low-grade rock phosphate or phosphatic clay
    b. Relatively insoluble, seldom recommended
7. Calcium metaphosphate
    a. Is 62-65 percent available phosphate in acidic soils
    b. Not recommended on alkaline soils; is insoluble

Other phosphorous fertilizers are available, but in limited or local areas. Their value should be determined by their solubility and relative price as compared to the more common, recommended phosphate fertilizers.

Potassium deposits in this country are sufficient for several generations. Principal known deposits are in New Mexico, California, and Utah; and recently more were also located in Canada. The potash in fertilizer is supplied by four important compounds: over ninety percent is muriate of potash (KCL); the remainder is sulfate of potash, sulfate of potash magnesia, and nitrate of potash.

Material	Percent Potash (K_2O)	1961 Tonnage
Potassium chloride (muriate)	60-62	247,000
Potassium magnesium sulfate	22	
Potassium sulfate	50	34,000
Potassium nitrate	45	
Total, separate materials		281,000
Potash used in mixtures		1,884,000
Total potash all fertilizers		2,165,000

The characteristics of the various potash materials in soil fertility are similar.

1. Muriate of potash (potassium chloride)
    a. 50-62% potash, water soluble
    b. Most common source of potash fertilizer

2. Sulfate of potash (potassium sulfate)

    a. Contains less chlorine than muriate and is favored by tobacco growers

    b. 50% potash, water soluble

3. Nitrate of potash (potassium nitrate)

    a. Contains nitrogen plus 45% potash

    b. Little commercial importance; imported from Chile

4. Potassium-magnesium sulfate

    a. Contains magnesium and 22% potash; both water soluble

    b. Sold under trade name "Sulpo-mag"

Tobacco by-products, potassium phosphate, and potassium-sodium nitrate are other potassium-carrying materials, but their use is limited.

Soils contain large quantities of potassium, but it is largely unavailable to plant growth. Liming increases the availability of potassium and reduces potassium leaching.

Fertilizers are sold in three forms--dry, liquid, and gaseous. Anhydrous ammonia is the only gaseous fertilizer. They may be straight materials, containing only one major nutrient; mixed fertilizers, containing two or more nutrients; and complete fertilizers, containing all three major nutrients of nitrogen, phosphorus and potassium. Over 60% of all fertilizers sold are mixed fertilizers. Dry fertilizers can be granulated, mixed, chemically blended, or made as a combination of the three.

1. Granulated fertilizers are converted into granules of uniform size, each containing the ingredients in the same proportion. This is called pelleting.

2. Chemically-blended materials, which are made into granules, chemically react to form materials of homogenous composition.

Fertilizers differ in their grade analysis. The common classifications are

1. Ordinary grade, containing a total value of less than 20 percent nitrogen, phosphate, and potash

2. High grade, containing 20-30 percent total plant food, such as 6-12-12

3. Concentrated grade, containing over 30 percent total nutrients, such as 12-12-12

The trend is to concentrated grade fertilizers for several reasons.

1. Economical transportation, handling, bagging, and storage

2. Reduced salt toxicity and less material needed to supply the needed amount of plant food

Lower grade fertilizers, however, generally contain more secondary and trace-elements and have a better physical condition. Concentrated liquid fertilizers are more likely to crystallize or "salt out."

Caking, the cementing together of fertilizer particles, is an undesirable characteristic of many fertilizers. It can be caused by

1. Recrystallization (chemical bonding of particles)

2. Moisture as the fertilizer takes on water

3. Pressure

The presence of fine materials, such as nitrogen materials, which are most likely to cake, accelerates the caking process. Several methods are used to prevent or reduce the degree of caking.

1. Drying below one percent moisture content and storing in low humidity buildings in moisture-proof containers and bags or bins controls caking.

2. Granulation reduces the surface area exposed to the atmosphere, thus permitting the absorption of less moisture.

3. Coating the granules reduces absorption of water and recrystallization.

4. Habit modifiers change the crystalline structure of the fertilizer to reduce recrystallization.

Other methods are also used to prevent caking. Fertilizers that resist caking appeal to users, and any anti-caking feature of a fertilizer is a major sales tool. Employees of the industry should be able to give advice on handling and storing fertilizer to prevent caking. Caked fertilizers require extra work in pulverizing and plug fertilizer applicators; and, in severe cases, the fertilizer may become unusable.

Suggested Teaching-Learning Activities

1. Collect samples of available fertilizer materials--nitrogen, phosphorus, and potassium--and have students learn to identify the ones with specific physical characteristics.

2. Secure samples of elemental phosphorus and potassium and present demonstrations to show their properties.

3. Collect samples of mixed, blended, and granulated fertilizers to show and discuss the differences present.

4. Expose various fertilizer materials to humidity and heat and observe those that cake.

5. Obtain samples of liquid fertilizers. By temperature control demonstrate crystallizations or "salting out."

6. With litmus paper, demonstrate the acidic or basic nature of various fertilizer materials.

7. With a fan, demonstrate separation of a mixed fertilizer and discuss this principle as it applies to fertilizer applications.

8. Place samples of the various fertilizer materials in tin cans in humid places. Note how some begin to react (rust) with the metal. Discuss how this affects the type of metals used for storing certain fertilizers and the care needed to protect fertilizer equipment.

9. Demonstrate the solubility of various fertilizer materials. Add fertilizer to water, permit time for it to dissolve, then filter it into clean petri dishes; allow water to evaporate. Note the accumulated salts. This may be done by using slightly acidic or basic water to show the effect of pH on solubility of certain fertilizer materials.

10. Collect caution or warning signs or labels used with the more toxic or dangerous fertilizer materials. Display them on a bulletin board, indicating to which material they apply.

11. Using local prices, have students work out a problem of recommending to the customer the strength of fertilizer solution to be used, based on the table of properties of selected nitrogen fertilizers on page 31.

Suggested Instructional Materials and References

Instructional Materials

1. Samples of fertilizer materials

2. Litmus paper, beakers, petri dishes, glass funnels, filler paper, tin cans, small fan

3. Signs or labels with fertilizer precautions

4. Film, What's in the Bag?

References

1. Dictionary of Plant Foods.

2. Our Land and Its Care, pp. 26-31; 44-45.

3. Profitable Soil Management, pp. 188-193.

4. The Fertilizer Handbook, pp. 73-80; 212-219.

5. Using Commercial Fertilizer, pp. 33-72; 99-105.

Suggested Occupational Experiences

1. Have each student become familiar with the fertilizer materials handled by his training center. This should include knowing names, analysis, form, use, price, and warehouse location.

2. Each student should gain experience in warehousing fertilizer correctly to avoid waste, and accurately filling orders for customers.

3. Each student should learn the volume and seasonal movement of the various fertilizers handled by his training center.

V. To interpret different fertilizer formulas

Teacher Preparation

Subject Matter Content

The ability to evaluate the probable effectiveness of a fertilizer is one of the basic skills needed by an employee in occupations pertaining to fertilizer sales and service. The student needs to know

1. The meaning of the numbers on a bag of fertilizer
2. The use of fertilizer ratios
3. How to compare values of various fertilizers
4. How to change plant food percent to elemental percent

In addition, students at the post-high school level should know how to formulate fertilizer, such as 5-20-20, 0-15-45, and 6-24-12.

The numbers on the bag refer to the percent of the three primary plant nutrients--nitrogen, phosphorus, and potassium--in that order and is the guaranteed analysis. A 6-24-12 fertilizer contains

1. 6 percent nitrogen (N)
2. 24 percent available phosphoric oxide (P_2O_5)
3. 12 percent soluble potash (K_2O)

This is a 42 unit (6+24+12) fertilizer and has a 1-4-2 ratio, determined by dividing all the numbers by the smallest. A 4-16-8 fertilizer would have the same 1-4-2 ratio but would contain 28 units of fertilizer. Assuming a customer wanted to apply 300 pounds of 4-16-8 per acre, but found that it was not available, 200 pounds of 6-24-12 would supply the same amount of primary nutrients--12 pounds of nitrogen, 48 pounds of phosphoric oxide, and 24 pounds of potash.

Mixed fertilizers often contain secondary or trace elements in addition to the primary elements. When a certain level is guaranteed, the amount must be stated on the bag. A popular grade in the orange country is 4-6-8-3-1-1½, with the last three numbers standing for magnesium, manganese, and copper. Where the amount is not guaranteed, just the fact that the nutrient is added is sufficient. In certain areas 0-15-45 B is a popular alfalfa fertilizer, with the B indicating that boron is added. Other fertilizers are sold as trace element fertilizers, such as "5-20-20 with trace elements added."

Pesticides--including insecticides, herbicides, fungicides, and rodenticides--have recently been added to some mixed fertilizers for farmers and gardeners. Insecticides have been widely used and accepted. Such a combination is advantageous in time and labor saved by applying both at once. They have, however, the disadvantage of not always being placed effectively when applied with the fertilizers. There will be an increased use of pesticides mixed with fertilizers, and sales persons or field men should know which materials can be used with specific crops. They should be familiar with the tolerances allowed so that they can caution the customers who use them. Care should be exercised in recommending the use of these materials until experience is gained, especially on home gardens.

Economics is an important consideration. Assume that 4-16-8 is priced at $60 per ton or $3 per hundred, and 6-24-12 is $80 per ton or $4 per hundred. This is a reasonable price relationship. Applying 200 pounds of 6-24-12 per acre would cost $8; whereas 300 pounds of 4-16-8 per acre would cost $9. Generally a high analysis fertilizer is the best buy; but sales-wise, there is likely to be more profit in selling 3 tons of 4-16-8 than there is in selling 2 tons of 6-24-12. The analysis to sell presents a problem in sales and service to the dealer. The best solution apparently is to sell the 6-24-12 and sell more tons.

The principal ratios and grades of mixed fertilizer sold in the United States are listed below. These make up over seventy percent of the mixed fertilizer tonnage used annually.

Ratio	Grades
1-2-2	5-10-10; 6-12-12; 8-16-16
1-4-4	4-16-16; 3-12-12; 5-20-20; 6-24-24
1-1-1	12-12-12; 10-10-10; 8-8-8
1-2-3	5-10-15; 4-8-12
1-2-1	5-10-5; 10-20-10
1-4-2	6-24-12
1-3-3	3-9-9
0-1-1	0-20-20
0-1-3	0-10-30; 0-15-45; 0-12-36

There is a trend toward higher analysis and varied ratio fertilizers since new processing methods have made fertilizers of higher analysis possible, and they are generally more economical for the dealer and the customer. With present manufacturing methods, a 54 unit (6-24-24) fertilizer is about the highest analysis possible for a complete fertilizer. Most liquid fertilizers contain fewer units.

Varied ratio fertilizers are being developed to meet special crop needs and certain soil requirements. Many fertilizer manufacturers formulate fertilizers to a farmer's own prescription, which creates a problem. Students should understand why there are no 80 or 90 unit fertilizers. If demonstrations showing the properties of elemental phosphorus and potassium were presented in the fourth competency, they should understand why 100 unit fertilizers are not available. One simple method of demonstrating fertilizer formulation is mixing basic fertilizer materials together in a class demonstration and then calculating what is present in the mixture. Weigh out

1. Three pounds of ammonium nitrate, 33.5% N
   33.5% x 3 = 1.05 pounds of N

2. Four pounds of treble superphosphate, 45% P_2O_5

3. Three pounds of muriate of potash, 60% K_2O

This mixture composes ten pounds of mixed fertilizer, containing 1.05 pounds of N (10.5%), 1.8 pounds of P_2O_5 (18%) and 1.8 pounds of K_2O (18%), or a 10-18-18 fertilizer. To make a ton would require 600 pounds of ammonium nitrate, 800 pounds of treble superphosphate, and 600 pounds of muriate of potash.

Development of a fertilizer formula is more than mere arithmetical calculation. Consideration must also be given to

1. The physical and chemical properties of the materials

2. Their cost and availability

3. Their physical state in relation to handling problems

4. The crops on which the fertilizer is to be used

There is considerable demand and some indication that the numbers on fertilizer bags will be changed to list the percent of available phosphorus and available potassium rather than the phosphoric oxide and potash percents now given. Some companies have begun to make this change. Students should be made aware of these changes, how such changes would affect the interpretation of numbers appearing on the bag, and the task of customer education which would follow.

Conversion factors for changing from
plant food to elemental basis

Phosphoric oxide to phosphorus - - -multiply by 0.4369
Phosphorous to phosphoric oxide- - -multiply by 2.2886
Potash to potassium- - - - - - - - -multiply by 0.8302
Potassium to potash- - - - - - - - -multiply by 1.2046

In the future, what now is a 6-24-24 fertilizer would become 6-19.4-19.9 fertilizer.

Each state controls the manufacture and sale of fertilizer within that state. All state laws require

1. Registration and accurate labeling of brands and grades. Bulk sales must include a sales slip indicating the brand and grade.

2. Guarantees of nitrogen, phosphoric oxide, potash percentage, and trace elements when listed

3. Assessment of penalties for failure to meet the guarantee

Fertilizers containing pesticides must pass state and federal regulations and be labeled to show

1. Type of pesticide contained

2. Amount of pesticide contained

3. Explicit instruction for use

Suggested Teaching-Learning Activities

1. Have students determine the grades, ratios, and prices of locally available fertilizers.

2. Have students calculate the fertilizer at each ratio that would be the most economical to buy.

3. Have students gain experience with changing plant food composition listed in per cent to the elemental basis.

4. Give students problems in formulating various mixed fertilizer grades using various basic materials.

5. Plan a field trip to a fertilizer industry to observe how fertilizers are calculated and mixed.

Suggested Instructional Materials and References

Instructional materials

1. Collection of fertilizer bags to show analysis

2. Fertilizer materials to demonstrate formulation of fertilizers

3. Copies of state fertilizer laws, available from the State Department of Agriculture

References

1. Our Land and Its Care, pp. 56-59.

2. The Fertilizer Handbook, pp. 81-82, 199-209.

3. Using Commercial Fertilizers, pp. 87-119, 217-224.

Suggested Occupational Experience

1. Have each student learn the grades and uses of the various fertilizer materials handled at his training center.

2. Have each student gain experience in recommending or substituting grades of fertilizer for customers.

3. If feasible, give each student experience in formulating grades of fertilizers.

VI. To understand the different methods used to determine the fertility needs of soils and to develop the ability to take soil samples

Teacher Preparation

Subject Matter Content

List with the students the methods used to determine the fertility needs of a soil, such as

1. Visual observation of soil and growing plants
2. Soil testing
   a. Farm testing
   b. Commercial testing laboratories
   c. State testing laboratories
3. Tissue testing
   a. Farm testing
   b. Commercial testing laboratories
   c. State testing laboratories
4. Field test plots
   a. Individual farm plots
   b. Industry demonstration plots
   c. State and federal agricultural experiment station test plots

Visual observation of soils to determine fertility needs is difficult, even for a soils scientist. True, the organic matter content and mineral matter content of a soil can be determined with some degree of accuracy by observation; but many soils which appear fertile are unproductive because of adverse pH or the lack of one or more essential nutrients, which are not visible. The keen student of plants can obtain some idea of plant needs by visual observation of such characteristics as color, leaf, shape, and growth habits. Many hidden hunger signs cannot be observed and usually cannot be corrected, since fertility problems causing them cannot be observed until late in the growing season.

Soil testing is the accepted method of determining the level of existing soil fertility. Annually, over two million soil tests are conducted by public and commercial laboratories in the United States. These chemical tests are valuable aids in planning a fertility program, but can be no better than the soil samples submitted for testing. Employees in the retail fertilizer industry need to be able to take accurate soil samples, give instructions, and demonstrate to customers the proper procedures for taking representative samples. The sample is small but must represent the entire field or area which is to be tested. A plow layer of soil on one acre weighs about two million pounds; and since most samples represent a field of five acres or more, the one-or two-pound soil sample must adequately represent ten million pounds or more of soil.

Rules for sampling soil vary from state to state, but the following are basic procedures generally followed.

1. Take soil samples to a depth of 2-3 inches for lawns and pastures and to a depth of 6-8 inches for field crops.

2. If the subsoil is to be sampled, that sample should not include any topsoil.

3. Do not include surface litter in the sample.

4. Use a soil probe or auger to obtain a uniform slice of soil down to the proper depth.

5. Include 12-20 slices or cores per sample, representing not more than 5-10 acres.

6. Use clean pail, tools, and containers for samples.

7. Sample separately each area which differs in crop, soil, or pest management.

8. Do not take sample slices from areas too small to fertilize separately, such as terrace channels, fence lines, dead furrows, tree areas, old manure piles, and others.

9. Mix the 12-20 slices or cores thoroughly.

10. Air dry the sample; do not heat it.

11. Number the sample, keeping a record of the location where it was taken.

12. Fill out completely an information sheet about the era sampled, including

a. Soil type

b. Previous crops and yield

c. Recent fertilization and liming programs

d. Irrigation practices

e. Crop to be grown

On the following page is a copy of a typical soil sample information sheet.

Soils are generally tested for pH, nitrogen, phosphorus, and potassium. However, tests are available in most states for checking the level of secondary and trace nutrients. Students will probably not be responsible for conducting soil tests; but since some retail fertilizer concerns do conduct tests for their customers, knowing a few basic principles of soil testing is desirable.

The first step in soil testing is thorough mixing and pulverizing of the soil sample. From that sample a measured sub-sample is taken, to which an extracting solution is added and then agitated. This material is then filtered. Colorimetric, turbidity, and electrometric methods are used to measure the level of pH and other available plant nutrients. One must have considerable knowledge to intrepret soil tests intelligently, and they should be done only by highly trained personnel.

Soil testing kits are available and are usually quite reliable. Before using such a kit in a specific area, check the results by sending identical soil samples to an official testing laboratory to see if the results are the same. Certain precautions must be followed when using these testing kits.

1. Be sure that the samples of soil are representative.
2. Check the reagents in the kit for shelf life and accuracy.
3. Use recommended laboratory techniques.
4. Read results accurately.
5. Interpret results by considering field conditions, and other factors affecting crop growth.

SOIL SAMPLE INFORMATION SHEET

Farmer's Name ____________________

Address ____________________

Date rec'd at laboratory ____________

Laboratory No. ____________

Farm Location ____

(County) (Township) (Section)

SOIL SAMPLE		
Field No.	Sample No.	No. acres in this sample

SOIL DESCRIPTION (Check Box)									
Slope				Erosion			Drainage		
level upland	gently rolling	roll-ing	bot-tom	slight	mod-erate	severe	good	fair	poor

PAST CROPPING AND MANAGEMENT

Field No.	Previous Crop (last year)	Yield	Measure Applied	Comments on Crop Appearance Soil Type--Special Problems

IRRIGATION

Is land irrigated?

Yes ☐ No ☐

If so, how?

Ditch ☐
Sprinkler ☐
Gated Pipe ☐

PREVIOUS FERTILIZER AND LIME TREATMENTS

Fertilizer Applied		Lime Applied	
Last Year			
Grade	lbs./A	Most Recent Years	Tons/A

CROPS TO BE GROWN

Crop	Measure to be Applied	Yield Goal

Soil test results are no better than the accuracy of the soil sample and the testing procedure. An inaccurate test result is probably worse than no test at all. Accurate soil testing sells fertilizer and can be a fertilizer dealer's most profitable service. Evidence indicates that

1. Over 90% of the farmers who test soil buy fertilizer.
2. Soil testing leads to greater customer profits, since a satisfied customer returns to do more business.
3. Testing soils and making fertilizer recommendations establishes the dealer as a "fertilizer consultant"; customers return for this type of service.

A third method of determining the fertility needs of soils and crops is plant tissue testing. Several plant tissue test kits are on the market. Most of these are colorimetric tests, since the nutrient content of the plant tissue is indicated by the changes in color caused by adding a chemical. It indicates whether the nutrient concentration in the plant is low, adequate, or plentiful. Instructions included with the kit must be carefully followed if the test is to be meaningful. These tests are called green-tissue tests. A second type of tissue test which is relatively expensive is the plant analysis test, made in laboratories by highly trained specialists. They are used most often by growers of high-value fruit and vegetable crops.

Green-tissue tests are advantageous because they

1. Reveal hidden hunger
2. Point up the need for soil tests
3. Verify observed deficiency symptoms
4. Determine the adequacy of plant nutrients
5. Serve as a guide to midseason fertilization for some crops

Tissue tests can be of real value to a fertilizer dealer, as they afford him an opportunity to serve his customers by better educating them and becoming better acquainted with them. This increases the confidence of the customer in the dealer, assists the customers in planning future fertilizer needs, and, in turn, results in extra fertilizer sales for the dealer.

Field test plots or demonstration plots are the most reliable methods of determining fertilizer needs and results. Visual observation, testing soil samples, and making tissue tests are all good guides, but the best way for a customer to find out whether he is using enough fertilizer is to make a test on his own land. This must be done carefully to avoid misleading results.

Demonstration plots are a valuable sales and service tool for the fertilizer dealer. They offer these advantages:

1. Proof is a strong selling point; seeing is believing.
2. Plots located and labeled on a well-traveled route are constant reminders to customers of the value of a sound fertility program.
3. Demonstration plots viewed by the customer develop confidence in a dealer and his product.
4. Interest is developed, which leads to sales.
5. Local plots bring broadly recommended practices to a local basis where they can be evaluated. They should be located as close to the farm supply store or fertilizer dealership as possible, to make it easy for salesmen to show a potential customer at the proper time.

Test or demonstration plots should be big enough to be representative, but small enough so that harvesting and checking the yield is not too difficult.

Probably from an ideal standpoint, an acre would be the smallest test that should be made, but many farmers want to test only a fraction of an acre. If very careful plans are followed, these fractional plots can be of considerable value. Information which follows assumes a test plot of 1/5 or 1/10 of an acre, or, as is sometimes done with row crops, 1/100 acre.

A test plot laid out near the center of the field or across a field, rather than along a field edge, is preferred. If a combine or mower is going to be used to harvest a plot, the test plot should be wider than the swath to be harvested. Check plots on which to base comparisons should always be established. Several test plots with different levels of fertility are desirable.

Area to Fertilize to Equal 1/5 Acre

Width	Make the strip this long
10 feet	872 feet
20 feet	436 feet
30 feet	290 feet
40 feet	218 feet

For pasture and forage crops, because of their large bulk, plots of about one-hundredth acre, located well away from fences are practical. If the field is to be grazed, these plots must be fenced until after yields are checked.

Mark each location with stakes so that it will not get lost, and complete a sketch in an account book to which to refer as a safety precaution. This sketch should include measurements of each location as well as rates used and other pertinent data.

Spread fertilizer as evenly as possible; double check to be sure the amount is what is desired. For example, if the test plot is 1/5 acre, the increased fertilizer applied on this area should be 1/5 the total amount desired per acre.

Plant in the normal manner, making no change in the planting done in the test area. The planting rate, however, must be sufficient to make use of the increased fertilization rate; otherwise, planting rate may cause no significant increase in yield.

Harvesting methods vary according to the crop tested, but two important rules should be followed on all crops.

1. Lay out accurately the area to be harvested near the middle of the test plot.

2. Lay out and harvest an area of equal size near the test plot for control purposes.

For row crops:

1. Measure accurately the area to be harvested in each plot. (See table on following page.)

2. Harvest by hand or by machine.

3. Weigh the amount harvested from each plot separately and record the results.

4. When computing the actual yield increase, be sure to consider moisture in grain crops.

Total Length of Row to Equal 1/10 Acre

Row spacing	Length of row
28 inches	2,008 feet
32 inches	1,632 feet
36 inches	1,450 feet
40 inches	1,320 feet
42 inches	1,240 feet

NOTE: 1/100 acre is 1/10 these lengths.

For small grains and flax:

1. According to the header width of the combine, determine length of swath necessary to equal the acre to be harvested. (See table below.)

2. Harvest a swath the designated length in each strip and on the same length adjacent to the test strip as a control. Be sure the combine is clean before starting to harvest each swath. On bulk combines, put a sack over the elevator spout to catch the grain.

3. Weigh the amount harvested from each plot separately and record the results.

Length of Swath to Equal 1/10 Acre

Width of swath	Length
5 feet	870 feet
6 feet	725 feet
7 feet	620 feet
8 feet	545 feet
10 feet	435 feet
12 feet	365 feet

4. Check for moisture content.

Hay crops may be harvested by mowing a one-hundredth acre or smaller strip in the middle of the test plot, and another adjacent to the test strip. Divide lengths shown in the table above by 10 to determine proper length for one-hundredth acre. Cure like hay in the rest of the field. Weigh cured hay from each plot separately and record results.

To determine pasture yields, every two or three weeks during the growing season, harvest an area of one square yard in the middle of each test plot. Weigh green and record results.

To make economic comparisons of the fertilized plots with the check plots, do the following:

1. Find the yield difference between the plots.
2. Multiply the amount of increased yield by the value per unit of the crop.
3. Subtract the cost of the extra fertilizer.
4. Determine the most profitable fertilizer level.
5. Use the results as a guide to fertilization of the following year's crops.

Greater net profit for a customer from the optimum use of fertilizer is the most effective sales tool available. Employees who make effective use of these methods of determining fertility needs, make wise fertilizer recommendations, and assist in establishing test plots to prove the results of the decisions will be effective in the fertilizer industry.

Suggested Teaching-Learning Activities

1. Show the slide set, How to Take a Soil Sample, and follow with demonstrations and student practice in collecting soil samples.
2. Show the film, The Big Test.
3. Arrange a field trip to permit students to take soil samples. Have them obtain and fill out a field information sheet. Have students "guess" the pH, nitrogen, phosphorus, and potassium levels. Compare their visual judgments with the soil test results.
4. Demonstrate soil testing to the class or visit a soil testing laboratory.
5. Demonstrate plant tissue testing to the students.
6. Arrange a field trip to a well-planned set of fertilizer test plots. Attempt to show visual differences in the plots.

Suggested Instructional Materials and References

Instructional Materials

1. Soil sampling equipment, including locally used information sheets
2. Soil testing kit
3. Tissue testing kit
4. Results of local fertility test plots
5. Colored slides, How to Take a Soil Sample
6. Film, The Big Test
7. Poster, How to Take a Soil Sample

References

1. How to Get Good Soil Samples.
2. How to Take a Soil Sample.
3. Hunger Signs in Crops.
4. Our Land and Its Care, pp. 35-36.
5. Profitable Soil Management, pp. 159-176.
6. The Fertilizer Handbook, pp. 84-101; 145-198.
7. Using Commercial Fertilizer, pp. 132-141.

Suggested Occupational Experiences

1. Have students take soil samples and fill out information sheets on lawns, gardens, and fields, at their home or school, or through the training center.
2. Have students assist in soil and/or tissue testing.
3. Have students gain experience with fertilizer test plots at home, school, or the training center.

VII. To interpret a soil test report

Teacher Preparation

Subject Matter Content

Soil test results normally report the following:

1. The pH of the soil
2. The organic matter and/or nitrogen content of the soil
3. The available phosphorus in the soil
4. The available potassium in the soil

More specialized soil test reports may contain information on these and other soil characteristics:

1. Secondary and minor element content in the soil
2. Color and texture of the soil
3. Soluble salt content of the soil

The pH test indicates the soil reaction of acidity or alkalinity. The desirable pH range for most crops on mineral soils is between 6.5 and 7.0. A pH range of 6.0-8.0 is adequate for most permanent grasses, and a pH of 5.2 or more is adequate for organic soils.

The organic matter, or nitrogen content, in the soils is reported in various ways by different public and commercial soil testing laboratories. Methods of reporting these results are by

1. Percent of organic matter in the plow layer per acre
2. Pounds or tons of organic matter in the plow layer per acre
3. Pounds of total nitrogen per acre
4. Pounds of available nitrogen per acre

The trend is toward reporting the amount of organic matter per plow layer acre either as a percent or as a weight figure. Notice that each one percent of organic matter in the plow layer equals ten tons of organic matter or 1000 pounds of total nitrogen per acre. This nitrogen is largely unavailable to the growing plant. In silt and clay loams, about two percent and, in sandy soils, about five percent of the total nitrogen is available for the coming year's crop.

Organic Matter in Soils

Levels, low to high	Organic matter in the plow layer		Total nitrogen pounds per acr
	percent	tons per acre	
Very low	1.0	10	1,000
Low	1.5	15	1,500
Med. low	2.0	20	2,000
Medium	2.5	25	2,500
Med. high	3.0	30	3,000
High	3.5	35	3,500
Very high	4.0	40	4,000

Phosphorus is reported on soil test reports as available phosphorus or as available phosphoric oxide. The trend toward reporting it as available phosphorus, in part, is evidence of the trend and interest in changing grades of fertilizer to the elemental basis.

Phosphorus in Soils

Levels, low to high	Amount available in the plow layer pounds per acre	
	Phosphorus	Phosphoric Oxide
Low	5	12
Med. low	10	25
Medium	25	60
Med. high	35	80
High	40+	90

The availability of phosphorus in the soil is closely related to the pH of the soil. Correcting the reaction of soils which are highly acidic or highly alkaline tends to make phosphorus more available. In like manner, adding phosphorus to soils too high or too low in pH does not substantially improve the available phosphorus content within the soil.

Potassium is reported as available potassium or available potash. Again the trend is to report available potassium on the elemental basis. Soils are generally high in total potassium, but only small amounts are available. The pH level in the soil is critical, as potassium becomes most available at a pH range of 6.5 to 7.5.

Potassium in Soils

Levels, low to high	Amount available in the plow layer, pounds per acre	
	Potassium	Potash
Low	100	120
Med.-low	125	150
Medium	150	180
Med.-high	175	210
High	200	240

Secondary and minor plant nutrients are normally not included in the soil test. On sands, mucks, and other soils where crop response appears to be limited, however, this type of test should be made. Results of these nutrient levels are generally reported as total pounds, available pounds per acre, or as parts per million. Care must be taken when recommending the use of some minor elements, as excessive amounts may be toxic. See Our Land and Its Care, page 34, for a map and information relative to minor element deficiencies in the United States.

Color and texture on a soil test report give an indication of a soil's potential productivity. Dark-colored loam soils are usually characteristic of a soil possessing high yield potential; light-colored sands normally are near the lower end of the productivity scale.

Testing soils for soluble salts is common in certain areas. The term soluble salts refers to the total soluble mineral element content of the soil. When the soluble salt content of the soil is very low, plant growth is poor because there is not enough fertilizer in the soil. Excessive soluble salts are associated with poor plant growth. The amount of soluble salts in a soil can be measured by electric conductivity tests. Since the scales used to measure the soluble salt concentration vary, one must know the scales to interpret the results.

Once a student can interpret a soil test report, he is ready to learn how to make a fertilizer recommendation to a customer.

Suggested Teaching-Learning Activities

1. Obtain copies of local soil test reports, and give students experience in
   a. Physically locating information on the report form
   b. Determining the methods used to report information--per cent, pounds, phosphorus or phosphoric oxide, and others
   c. Interpreting the report to determine the level of fertility of the field covered by the report
2. The opaque or overhead projector is effective in showing those parts or columns on the report sheet on which you want the student to concentrate.

Suggested Instructional Materials and References

Instructional Materials

1. Blank copies of soil test report forms
2. Completed copies of soil test report forms
3. Overhead projector transparencies

References

1. *Our Land and Its Care*, pp. 33-36.
2. *Profitable Soil Management*, pp. 168-169.
3. Most states have publications to assist in interpreting soil tests which may be obtained from the state's agricultural experiment station.

Suggested Occupational Experience

Students should gain experience at the training center interpreting soil test reports for customers.

VIII. To make fertilizer recommendations

Teacher Preparation

Subject Matter Content

Several factors should be considered when making fertilizer recommendations even after an accurate soil test report is available. Determine with the students what these factors are. Among them are the following:

1. Desired yield. Will the customer always desire maximum yield or maximum profit, or is he satisfied with a lesser goal?

2. Nutrient requirement of crops. As an example, see The Fertilizer Handbook, pp. 54-55.

3. Capability of the soil. Not all soils are capable of producing 100 bushels of corn, 40 bushels of wheat, or 4 bales of cotton per acre.

4. Climatic conditions, such as rainfall, temperature, and length of growing season.

5. Previous crop history of the field will provide helpful information. Find out about

    a. Previous fertilizer response

    b. Recent applications of lime, fertilizer, and manure

    c. Use of legumes in the previous rotation

    d. Visual observations, tissue tests, and test plot results of previous year's crop.

Since all this information is seldom available, crop yield goals are established by using the customer's suggestions and experience, in addition to available information.

There are two major types of fertilization programs.

1. Corrective application. This can be a rather heavy application of fertilizer to bring soils up to a high level of fertility. Some states and commercial companies recommend that this be a rapid one- or two-year treatment; others recommend a more gradual fertility correction program.

2. Maintenance application. This is a fertility program whereby the level of fertility is maintained by adding to the soil nutrients equal to the amount removed by the crop each growing season.

The first step in all fertility programs is adjusting the soil pH to the desirable range. This is accomplished with lime or liming materials on soils with a low pH. Lime requirements vary by soil type and relative acidity of the soil. The approximate amounts of finely ground Grade A agricultural limestone needed to correct the pH of various soils is indicated in the following table.

Soil regions and texture class	Limestone requirement per acre in tons	
	pH 4.5 - 6.5	pH 5.5 - 6.5
Warm-temperate regions		
Sands & loamy sands	.7	.4
Sandy loams	1.2	.7
Loams	1.8	1.0
Silt loams	2.6	1.4
Clay loams	3.5	2.0
Mucks	7.1	3.8
Cool-temperate regions		
Sands & loamy sands	1.1	.6
Sandy loams	2.1	1.3
Loams	2.9	1.7
Silt loams	3.5	2.0
Clay loams	4.1	2.3
Mucks	8.1	4.3

Sulfur or sulfur compounds are used to lower the pH of alkaline soils. The approximate amount of sulfur (95% S) needed per acre to lower the soil to a pH of 6.5 is given in the following table.

Existing Soil pH	Broadcase application of sulfur needed to bring soil pH to 6.5	
	Sandy Soils	Clay Soils
7.5	500#/A	900#/A
8.0	1200	1700
8.5	1700	1700
9.0	2500	

Once the soil reaction has been corrected, correcting the levels of nitrogen, phosphorus, and potassium in the soil can be accomplished by adding manure or commercial fertilizer and/or by plowing under green manure or crop residues. One ton of manure adds approximately the equivalent of 100 pounds of 10-5-10 fertilizer. Addition of fifty pounds of 0-20-0 per ton of manure reduces the loss of nitrogen (ammonia) and provides more balanced fertilizer.

Plowing under a good stand of legumes makes available about forty pounds of nitrogen for the next crop, but plowing under organic matter low in nitrogen, such as straw and corn stover, reduces the amount of nitrogen available to the next crop. It is recommended that at least thirty pounds of nitrogen be plowed down with each ton of non-nitrogenous organic matter. Ninety pounds of nitrogen should be applied to the stover from a good corn crop weighing about three tons.

Not all the plant food available in the soil, whether added by means of organic matter or commercial fertilizers, is usable by the next growing crop. The following table gives the approximate percentages of nitrogen, phosphate, and potash present in available forms in soils, available as manure and fertilizer that may be obtained by the first crop grown.

Sources of the three primary nutrients	Percentages of available nutrients obtained by first crop grown		
	Nitrogen	Potassium	Potash
Soil (of available present)	40%	40%	40%
Manure (of total present)	30	30	50
Fertilizer (of available present)	60	30	50

A typical fertilizer recommendation problem follows. Past history and available information indicate that a field is capable of producing 40 bushels of wheat per acre. The crop nutrient table (The Fertilizer Handbook, pages 54-55) indicates that growing this crop requires

1. 70 pounds of nitrogen

2. 30 pounds of phosphate

3. 50 pounds of potash

For the problem, the soil test reads

1. 120 pounds of available nitrogen
2. 30 pounds of available phosphorus*
3. 150 pounds of available potassium*

*Note that the crop requirements are given as phosphoric oxide and potash, whereas the soil test reports them as phosphorous and potassium. One must be converted.

30 x 2.2886 = 69 pounds of available phosphate

150 x 1.2046 = 181 pounds of available potash

With the needs of the crop determined and the results of the soil test available, formulation of the fertilizer recommendation can be made.

Fertilizer Prescription - 40 Bushel Wheat

Source of Nutrient Element	Nitrogen		Phosphate		Potash	
	Pounds Present	lbs. crop can obtain	Pounds Present	lbs. crop can obtain	Pounds Present	lbs. crop can obtain
Soil (by test)	120	40%-80	69	40%-28	181	40%-72
200 lbs. of Aqua Ammonia 20-0-0	40	60%-24	--	-----	---	------
Total Crop May Obtain		72		28		72
Total Crop Needs		70		30		50

Notice that the nitrogen and phosphate are nearly balanced, whereas the soil contains more potash than the wheat crop requires. There is a shortage of two pounds of phosphate. Should phosphate fertilizer be added to correct this?

The Fertilizer Handbook, page 118, gives another typical fertilizer recommendation; this one is for a yield of 100 bushels of corn.

The tables included in this competency should be reproduced and the students given experience in formulating fertilizer prescriptions for local crops with typical soil tests and fertilizer materials.

In the previous example aqua ammonia was used to balance the nitrogen requirement. If aqua ammonia were not available, how would the amount of a different nitrogen fertilizer to be used be determined?

Material	Percent Nutrient	Pounds Needed	Calculations
Aqua Ammonia	20	40	40 ÷ 20 = 200 lbs.
Ammonium Nitrate	33.5	40	40 ÷ 33.5 = 119 lbs.
Urea	46	40	40 ÷ 46 = 87 lbs.

These procedures suggested to formulate recommendations are not always necessary. Frequently, the soil testing laboratory will have determined those recommendations, or the fertilizer dealer will have tables to which to refer that have standard recommendations listed for various soil fertility levels and yield potentials. A competent employee, however, should be able to make these recommendations for customers when requested.

Making fertilizer recommendations without soil tests is hazardous, at best. Nevertheless, this is frequently required. If a customer does not have a soil test, usually other information is also lacking, such as:

1. Previous yields
2. Visual observation of crop response
3. Soil type and productive potential

About all the information available is

1. Crop to be fertilized
2. Desired yield
3. General knowledge of the potential of the soil and the customer's ability

In the absence of state experiment station recommendations, the following general recommendations may serve as guidelines and may be used by the students:

1. The customer normally uses less than the desired amount of fertilizer.
2. For established legumes, fertilizer ratios of 0-1-1, 0-1-2, and 0-1-3 are most common.
3. For establishing legumes, fertilizer ratios of 1-6-6 or 1-4-4 are recommended.
4. For grasses, pasture, and lawns, a 2-1-1 ratio is most often used.
5. For small grains where legumes are not seeded, many fruits and vegetables, and flowers, a 1-2-1 ratio is recommended.
6. For a corn starter, 1-4-4 or 1-3-3 ratio is most common, with 50-100 pounds of additional nitrogen plowed down or side-dressed.
7. Root crops require a 1-2-2 or 1-2-3 ratio.

The best information a fertilizer salesman can give a customer that has not made a soil test is how and where he can obtain soil tests. The fertilizer salesman also can offer to take a soil sample for the farmer and send it to an independent laboratory for analysis. Fertilization without soil tests is much like running a clock without hands: neither makes much sense.

Employees in the retail fertilizer industry can expect to be asked for advice on fertilizer application. The questions will deal with

1. Methods
2. Time
3. Placement

Applying fertilizer depends on the crop, soil, climate, date, rate of growth, kind of fertilizer, and equipment used. The aim is to apply the correct amount at the correct time and place it where it will do the most good. Methods change as the rate of application increases. Common methods of application are:

1. Banding along the row
2. Broadcasting or top-dressing
3. Side-dressing
4. Drilling
5. Deep drilling
6. Bedding
7. Plowsole application
8. Foliar application
9. In irrigation water

The time of application varies widely by crop, soils, and area. Certain principles that relate to time are as follows:

1. Apply as late as possible before the plant needs the nutrient as is feasible if leaching or fixation is a problem.
2. Where leaching or fixation is not a problem, apply during the slack labor season.
3. Apply lime or sulfur one to two years ahead of major fertilization programs.

Placement of fertilizer is a critical problem.

1. Band application of phosphorus and potassium reduces fixation.
2. Place starter fertilizer near the root zone.
3. Excessive amounts of fertilizer in contact with seeds or young seedlings can be toxic.
4. Phosphorus and, to a lesser extent, potassium, are immobile in the soil.

5. Gaseous fertilizers must be deep placed to reduce losses to the atmosphere.

6. Broadcast application is lost in areas of erosion.

The pamphlet, Methods of Applying Fertilizer, is an excellent reference for principles of fertilizer use and recommendations for fertilizer application for most commercially produced crops in the United States.

Suggested Teaching-Learning Activities

1. The students should gain considerable experience in formulating fertilizer recommendations. Hypothetical problems should be developed for the students to work. Their recommendations should be checked for accuracy and logic. Duplicate the forms on pages 63-64 for class use.

2. Use local cases to prepare actual fertilizer recommendations.

3. A local dealer may explain to the class methods used in formulating fertilizer recommendations.

4. Use role playing to develop competition and confidence on the part of the students.

Suggested Instructional Materials and References

Instructional Materials

1. Copies of local soil test reports

2. Blank work copies of the form on page 118 of The Fertilizer Handbook

3. A large locally-made chart showing nutrient needs of the major local crops

References

1. Methods of Applying Fertilizer
2. Our Land and Its Care, pp. 24-25, 36, 46-49.
3. Profitable Soil Management, pp. 179-188.
4. The Fertilizer Handbook, pp. 18, 36, 83, 101, 108, 118.
5. Using Commercial Fertilizers, pp. 139, 142-162.

Suggested Occupational Experience

Students should gain experience making general fertilizer recommendations for customers. They should also gain experience in determining when to not give advice to a customer, but instead, refer him to a more technically trained person qualified to do so.

IX. To understand basic principles of fertilizer manufacture and plant operations

Introduction

The extent to which this competency should be used with high school classes should be determined by the teacher in the light of the individual abilities of the students and their employment potential.

Teacher Preparation

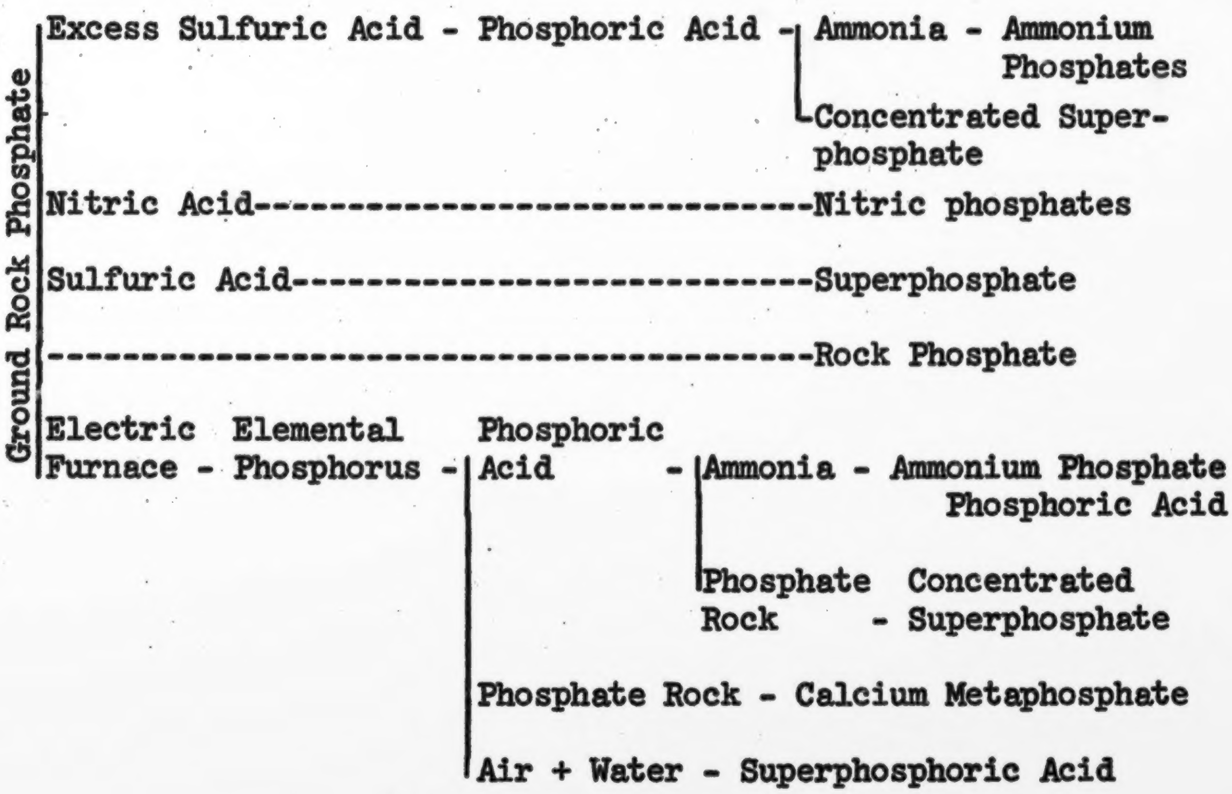
Subject Matter Content

Before the discovery of an economical method of manufacturing ammonia, the major sources of nitrogen fertilizer were mined nitrate of soda ($NaNO_3$), organic nitrogen materials, and the ammonia recovered as a by-product of the coke industry. Today most nitrogenous fertilizers are the result of the synthetic-ammonia industry. Ammonia is manufactured by combinining nitrogen and hydrogen under pressure in the presence of a catylst. Ammonia is the "start" to nearly all of our nitrogenous fertilizers.

Ammonia
- Oxygen - Nitric Acid---
  - Phosphate rock - Nitric Phosphates
  - Ammonia - Ammonium Nitrate
  - Sodium Carbonate - Sodium Nitrate
  - Calcium Carbonate - Calcium Nitrate
- Carbon dioxide------------------------------Urea
- Sulfuric Acid--------------------------Ammonium Sulfate
- Ammonium Nitrate + Water---------------Ammonium Solutions
- Ammonium Nitrate + Urea + Water---------Ammonium Solutions
- Urea + Water--------------------------Ammonium Solutions
- Phosphoric Acid-----------------------Ammonium Phosphates
- Under Pressure------------------------Anhydrous Ammonia
- Water-------------------------------Aqua Ammonia

Ammonia (NH_3) is "burned" by the presence of oxygen (O_2) to form nitric acid (HNO_3). In turn, nitric acid reacts with various materials, i.e., phosphate rock, to form some of the common fertilizer materials. Ammonia can also react with certain materials to form other nitrogenous fertilizers in very simple or very complex processes. Ammonia is manufactured by fewer than one hundred large companies; it is used to manufacture other nitrogenous fertilizers by approximately 1,500 fertilizer manufacturers across the nation.

Rock phosphate is a mined material, most of it coming from Florida. It is mined, washed, concentrated, dried, and shipped to manufacturing plants. The phosphate rock is then finely ground and processed into the various fertilizer materials. Note that certain phosphate fertilizers can be manufactured in more than one way.


Ground Rock Phosphate
Excess Sulfuric Acid - Phosphoric Acid -
Ammonia - Ammonium Phosphates
Concentrated Superphosphate
Nitric Acid
Nitric phosphates
Sulfuric Acid
Superphosphate
Rock Phosphate
Electric Furnace - Elemental Phosphorus - Phosphoric Acid -
Ammonia - Ammonium Phosphate Phosphoric Acid
Phosphate Rock - Concentrated Superphosphate
Phosphate Rock - Calcium Metaphosphate
Air + Water - Superphosphoric Acid

Crude potash salts, varying in composition, are either mined or recovered from lake dunes. These materials are then processed in large refineries into various potash materials. Muriate of potash can be used as it is mined; but it is generally refined or concentraded by a process requiring dissolving in water and recrystallization. Muriate of potash or potassium chloride is sold as a solid material but is also the most common potassium material used in formulating liquid fertilizers.

Potassium nitrate is a natural product mined in Chile, but most United States production is manufactured by treating potassium chloride with ammonium nitrate or sodium nitrate.

Potassium sulfate is made by treating potassium chloride with sulfate of magnesia or sulfuric acid. It is also manufactured by burning sulfur; the sulfur dioxide reacts with potassium chloride to form potassium sulfate.

Potassium-magnesium sulfate is found as a mineral called longbienite. It is processed to remove undesirable minerals by washing and centrifuging, and is then dried and marketed under a trade name such as "Sul-Po-Mag."

Liquid fertilizers are manufactured in two general ways. The more simple, but more costly, method is the batch process, whereby solid plant foods are dissolved in water to obtain the desired grade. Heating is desirable to hasten the dissolving of the solids. The neutralization process is more common and is based on neutralization of phosphoric acid with ammonia or with an ammonium product. Additional nitrogen and/or potash is added to obtain the desired grade.

Fertilizer plants can be described as being of two types.

1. One type is for the processing or manufacture of raw materials into concentrated fertilizer materials. These are generally located near the source of raw materials to reduce bulk handling and costs of transporting.

2. Finished fertilizer plants are best located close to the market area. These plants usually manufacture 10,000 to 50,000 tons annually. They require

    a. Access to good receiving and shipping facilities

    b. Storage facilities for raw materials

    c. Mixing and blending facilities

    d. Ban and/or bulk storage facilities for finished products

    e. Curing or conditioning facilities

    f. A quality-control laboratory

    g. An office

A plant manufacturing fertilizer for the consumer must use care in selection of ingredients. These ingredients must

1. Give satisfactory plant growth
    a. Contain the correct plant nutrients
    b. Have the correct nutrient form, such as nitrate or ammonia
    c. Be free of toxic compounds or other undesirable materials
    d. Contain as little "filler" material as possible
2. Have a reasonable cost per pound of nutrient
3. Be available in adequate quantities
4. Have the proper physical and chemical characteristics relating to
    a. Moisture content
    b. Hygroscopicity
    c. Reaction with other ingredients
    d. Heat of reaction
    e. Particle size
    f. Specific gravity
    g. Conditioning properties

The fertilizer industry operates on a critical yearly cycle which creates problems in manufacture and merchandising. In addition, many fertilizer materials are by-products of other industries. There is a peak demand for fertilizer at the time of planting and a lower demand during the other seasons. The young employee who realizes this and other attendant problems which are imposed on the manufacturer and dealers, can be of real value to his employer by making off-season sales or obtaining fertilizer orders to even out seasonal demand. Profits in the fertilizer business are determined by inventory turnover, ranging from one to three times, and by volume. Both of these are controlled by sales.

Suggested Teaching-Learning Activities

1. Arrange a field trip for the class to a fertilizer plant where manufacturing or processing methods can be shown.
2. Determine the source of the basic fertilizer materials used in your locality and the location of regional fertilizer plants. Determine how phosphate, potash, and nitrogen arrive in your area.
3. Make a map of the United States, showing the source of fertilizer raw materials and the routing of these materials to your area.
4. Use the overhead projector to show the steps in the manufacture of the various fertilizer materials. See The Fertilizer Handbook, pp. 74 and 77.
5. Show the film, What's in the Bag?
6. Have each student determine the source, mode of transportation, tonnage handled, and inventory turnover of the fertilizers handled at his training center.

X. To understand how to advise customers about the selection, calibration, and maintenance of fertilizer equipment

Teacher Preparation

Subject Matter Content

Much of existing fertilizer equipment is outdated or is so poorly maintained that maximum results from fertilizer cannot be obtained. Fertilizer application equipment must

1. Provide even distribution
2. Place the fertilizer properly

It is not enough that the applicator put on the desired amount per acre; it must put on the desired amount for each plant and in the right place. Only then will the fertilizer be able to provide best results.

A wide variety of application equipment exists because of

1. Types of fertilizer materials used
2. Varying rates of application needed
3. Varying placements desired
4. Areas to be fertilized

There are fertilizer applicators for

1. Applying fertilizer alone
2. Applying fertilizer and seed in one operation
3. Tilling and applying fertilizer in one operation
4. Applying fertilizer in liquid, solid, or gaseous forms
5. Applying fertilizer through irrigation systems
6. Applying fertilizer by airplane

Types of equipment available to apply fertilizer are

1. Hand-operated machines, both wheelless and wheeled
2. Broadcasters
    a. Full-width trailers
    b. Trucks, trailers, tractors, and wagons with spreading attachments, such as
        1) Rotary fans
        2) Full-width hoppers
        3) Auger spreader tubes
3. Row distributors and drills
4. Machines with fertilizer attachments, such as
    a. Drills
    b. Planters
    c. Tillage equipment

5. Liquid and gaseous fertilizer equipment
    a. Anhydrous ammonia
    b. Low pressure solutions
    c. Non-pressure solutions
    d. Foliar sprays
6. Airborne fertilizer equipment

When advising a customer on the type of applicator to buy, consider the following factors:

1. The applicator should be flexible in operation to meet the requirement of most fertilizer application.
2. The applicator should be easy to fill and should carry a large load.
3. The applicator should apply large or small amounts accurately and be easily adjusted.
4. The applicator should correctly place the fertilizer.
5. The applicator should be of sturdy construction and easy to maintain, and should resist corrosion. Newly-developed alloys and fiber glass products have aided in reducing problems of corrosion.
6. The applicator should be easy to empty and clean.

To be of service to customers, students should know how to calibrate fertilizer applicators. The following is a simple procedure which may be used to calibrate fertilizer applicators and nearly all other solid and liquid applicators.

1. Adjust applicator to the estimated rate.
2. Catch discharged fertilizer in a can, bag, or canvas.
3. Travel 40 rods (660 feet) at normal speed.

4. Weigh the amount caught and compute as follows:

$$\frac{\text{Pounds caught} \times 66}{\text{Width of application in feet}} = \text{pounds per acre}$$

Example:

$$\frac{40\# \times 66}{8'} = 330 \text{ pounds per acre}$$

5. Readjust the applicator and follow the same procedure until the desired rate of application is achieved.

Both high and low pressure liquid and gas applicators have metering devices to control the rate of application. They must be checked periodically for accuracy according to the operator's manual.

Since fertilizer applicators are normally used only a few days a year, they seldom wear out. The chief enemies are rust, corrosion, and decay. They should always be

1. Stored in a clean, dry shed
2. Thoroughly cleaned, including washing, before storage
3. Well coated with grease on all moving parts
4. Completely inspected and conditioned

Before using the applicator the following season, the operator should

1. Remove the coating of grease with solvent or kerosene
2. Check to see that all moving parts are moving freely
3. Check all operating adjustments
4. Lubricate the implement thoroughly

Consult the operator's manual for specific instructions on the care and operation of a particular applicator.

Suggested Teaching-Learning Activities

1. Determine with the students the types of fertilizer applicators used in the area. Discuss the characteristics of each type and the reasons for the varying types.

2. Arrange a visit to a farm machinery dealership to become acquainted with the various types of applicators available. Have the dealer explain the advantages and disadvantages of each type.

3. Give students experience in calibrating various types of applicators.

4. Bring a couple of the common types of applicators into the school shop and give students experience in making needed repairs and adjustments.

Suggested Instructional Materials and References

Instructional Materials

1. Wall charts, pictures, and colored slides of various types of applicators

2. Applicators for shop instruction

3. Operator's manuals for fertilizer applicators

References

1. The Fertilizer Handbook, p. 101.

2. Using Commercial Fertilizer, pp. 163-181.

Suggested Occupational Experiences

1. Have students gain experience at the training center, school, or home in maintaining and calibrating fertilizer applicators until they are proficient.

2. Have each student gain experience at his training center in the care, repair, cleaning, adjustment, and operation of all applicators the training center might have.

XI. To merchandise fertilizer effectively

Teacher Preparation

Subject Matter Content

The retail fertilizer business, like other retail businesses, depends on customers--old customers, new customers--but most of all, on satisfied customers. Why do customers change dealers? Survey results show that the reasons for change are as follows:

1. Three percent move away.
2. Five percent take their business to friends that are competitors.
3. Nine percent change because of price.
4. Eighty-three percent of all customers take their business elsewhere because of shortcomings on the part of sales personnel. These include
    a. Poor service
    b. Discourteous treatment
    c. Indifferent dealer attitudes

These statistics give a clue to effective merchandising of fertilizer. Little can be done to hold the business of customers that move or patronize friends, but effective sales and service programs can keep the other 92 percent of the customers and gain many new customers.

There are four basic areas in which effective sales and service in the fertilizer business can be accomplished.

1. Keep current on new technology.
2. Use effective advertising ideas
3. Strengthen your sales and service ability
4. Create enthusiasm for the product or service being sold

Become the best informed person in your business in your community. Be able to give advice to instill customer confidence in your ability. You keep current on new technology through a continuous self-education program as long as you merchandise fertilizer or any other product.

1. Study and know your products and those of your competitors.
2. Keep current on the results of recent college of agriculture, local, and U.S.D.A. fertilizer trials. Be able to report these findings to customers.
3. Keep your ears open. Learn what customers like and dislike about your products and services.

One should never run out of effective advertising ideas. The business with the new, novel, and progressive techniques attracts new customers and maintains the old as long as the service and attitude of the business to the customer are also superior. Advertising aids a fertilizer dealer by

1. Identifying products and services with your firm
2. Selling ideas
3. Making consumers aware of needs
4. Increasing your sales of products and services

Several advertising media can be used to help merchandise fertilizer.

1. Direct mail
2. Newspaper ads } usually a cooperative arrangement with the manufacturer
3. Radio commercials
4. Television commercials
5. Signs
    a. Billboards
    b. Fence hangers
    c. Field signs

    d. Building identification
    e. Truck and equipment decals

6. Handouts
    a. Information folders
    b. Sample bags
7. Specialties
    a. **Pens** and pencils
    b. Rain gauges and other small items
8. Demonstration plots and field days
9. Open house activities
10. Farmer meetings

Methods of promoting and developing interest in the fertilizer business are nearly unlimited, but what is effective in one community may fail in another. Customers should become acquainted with products and services by the most effective advertising media available.

Advertising alone does not sell products or services. In addition, a strong sales and service program must be provided. Earlier it was suggested that employees should be current on new technology. This is a "must" to provide the effective sales and service the present-day customer demands. Additional ways of strengthening sales and service ability are

1. To be aware of the customers' needs
2. To offer assistance in the proper use of products and/or services
3. To provide a soil testing and prescription service for customers
4. To develop programs to increase "off-season" sales
5. To provide educational programs to enable customers to better understand products and services and their correct use.
6. To make the kind of sale and provide the type of service that makes money for the customer

An enthusiastic salesman or serviceman is the best means of creating an enthusiastic customer. Certainly a sales or service person that is not excited about his product or work will not develop much interest in the customer.

1. Know the advantages your product and service has for the customer.

2. Show the farmer the success he has had with your products or service.

3. Compliment the customer on his wise decision in using your product or service.

Nothing generates enthusiasm like enthusiasm. An employee can develop this when he knows that he is providing products or service that can benefit the customer.

A characteristic of the fertilizer industry that complicates merchandising is the present seasonal use of fertilizer.

To merchandise fertilizer effectively, one must understand the customer. The average customer uses less than 50% of the fertilizer he could effectively and economically use. Three main factors keep farmers from using the correct amount of fertilizer.

1. Lack of knowledge

2. Fear of adverse effects

3. Lack of money or credit

To overcome the problem of lack of knowledge, the following suggestions should be helpful:

1. Talk about fertilizer in simple terms.

2. Interest the farmer in the results of properly using fertilizers. Talk about additional income, not additional costs.

3. Sell the right kind of fertilizer, not just fertilizer.

4. Use authoritative information from a source the customer respects. Do not oversell. Farmers have minds of their own and must be shown, rather than coerced.

The fear of adverse effects from the use of fertilizer may be difficult to overcome. The customer fears that higher levels of fertilization may be lost in years of adverse climatic conditions and even reduce crop yields. Recent research indicates that this is untrue. Fertilizer is almost the only crop expense that is not lost in years of low moisture, since it will be available for subsequent crops. In years of low moisture, properly fertilized crops make better use of the available moisture than do crops that are grown on soils lacking in fertility.

Customers, especially farmers, use the argument that they lack the money or credit to purchase additional fertilizer. This is largely a self-imposed psychological limitation based on handed-down attitudes and lack of knowledge. The principal reasons are

1. Lack of understanding of the economic benefits to be obtained

2. Reluctance to go into debt

3. Lack of knowledge of the availability of loans and the wise use of production credit

Understanding his customers should help an employee develop better techniques in advertising, sales, and service which will make him a more effective employee for the retail fertilizer business and of value to his customers.

Suggested Teaching-Learning Activities

1. Develop methods by which an employee in the retail fertilizer business can keep current with new technology as it develops.

2. Have students collect examples of advertising used by local concerns.

    a. Determine the main point of the advertisement.

    b. Discuss how the advertisement could be made more effective.

3. Have students develop sample advertisements for the use of XYZ brand fertilizer. Discuss the effectiveness of each advertisement. (The development of comprehensive advertising programs and display materials is more appropriate for post-high school courses.)

4. Considering the natural resistance that customers have for purchasing fertilizer, discuss the methods that would be effective in overcoming this resistance.

5. Have students obtain results from recent fertilizer studies and explain how they could be effectively used in merchandising fertilizer.

6. Visit a test plot or field demonstration that is designed to educate customers in the use of fertilizer. Discuss how these plots or demonstrations can be used to obtain maximum effect.

7. Have a resource person from a credit agency discuss the availability and the use of credit for purchasing fertilizer.

8. Have the students take or collect pictures of local producers out in their fields where test plots are being used to provide material for sales presentations.

9. Have students develop lists of persons who are using a particular fertilizer product or formula to be used in discussing sales with potential customers in their cooperative occupational experience center.

Suggested Instructional Materials and References

Instructional Materials

1. Several examples of advertisements used by local retail fertilizer concerns

2. Copies of the results of state or local fertilizer trials

3. Copies of local credit instruments used for financing the purchase of fertilizer

Reference

The Fertilizer Handbook, pp. 1-12

Suggested Occupational Experience

1. Have students assist in development of advertisements at their training centers.

2. Have students gain experience in selling fertilizer to customers.
3. Have students gain experience in working with demonstration days, farmer meetings, and other activities used to inform customers of the products and services of their training centers.

XII. To understand the importance of the fertilizer industry and its future trends

Teacher Preparation

Subject Matter Content

The introduction to this module states that twenty percent of the agricultural production in this country can be credited to the use of commercial fertilizer. Yet, the crop farmers of this nation are using less than 50% of the fertilizer that should be used according to studies conducted by the U.S.D.A. Thus, there exists a real challenge in educating farmers to expand the use of fertilizer.

The fertilizer industry is one of the largest industries in the chemical field, having doubled in size in the past twenty years and expected to double again in the next twenty years.

Directly or indirectly, the fertilizer industry can be credited with much of the advancement in crop production on our nation's farms, without which this would be a nation of want rather than a land of plenty.

Predicting future trends is hazardous, but indications are that in the fertilizer industry these trends will continue or develop

1. Expanded use of fertilizer per acre of farm land
2. Expanded use of fertilizer on non-farm land, such as
    a. Home lawns
    b. Parks
    c. Cemeteries
    d. Highway sides
    e. Golf courses

   f. Athletic fields

   g. Fish ponds, etc.

3. Use of higher analysis fertilizers

4. Larger demand for bulk fertilizers

5. More analysis fertilizers and special mixes for prescription applications

6. Better informed customers requiring better trained sales and service representatives

7. Decentralization of the fertilizer industry, with increased numbers of local mixing, blending, and distribution outlets

8. Increased services provided by fertilizer distributors

9. Improved application techniques, permitting higher levels of application, more even distribution, and more effective utilization by the crop

10. Better understanding of soil management, which will assist in more accurate fertilizer recommendations

The growth and future of the fertilizer industry appear to be limited only by the promotional activity of the industry. The need for additional use of fertilizer is present; now the personnel within the industry are responsible to acquaint the customer of his needs and the benefits that can be derived from additional use of commercial fertilizer.

Suggested Teaching-Learning Activities

1. With the class, make an estimate of the fertilizer tonnage that could be effectively used by farmers and non-farmers in your community's service area. Compare this with the approximate tonnage currently used. What does this indicate about the potential of the retail fertilizer industry in your community?

2. Have a panel consisting of the county agent, a leading farmer, and a person from the fertilizer industry discuss with the class the future and the trends of the retail fertilizer industry's role in the community in the next few years. What additional services do they anticipate providing to customers?

Suggested References

1. The Fertilizer Handbook, pp. 1-12.
2. Using Commercial Fertilizer, pp. 6-15.

Suggested Occupational Experience

Have each student conduct a study to determine the additional products and services customers desire from the training center at which he is employed.

Suggestions for Evaluating Educational Outcomes of the Module

Students should be evaluated on their ability to use the content of this module effectively. Basic understandings of the various competencies can be evaluated by classroom discussion and testing.

The ability to translate these understandings to particular problem situations in an occupational experience situation can best measure the effectiveness of this module. The employer-cooperator should evaluate the student in these areas of competency. A form questionnaire, such as the one on the following page, is a useful tool.

Name of Trainee____________________________________

Name of Cooperator__________________________________

Please evaluate the trainee on his ability to accomplish the following tasks in the retail fertilizer business. Please check the appropriate column.

Skill	Highly Competent	Competent	Incompetent
Understanding of fertilizer use			
Understanding of the nutrient requirement of crops			
Ability to "read" hunger signs			
Understandings of the properties of soil			
Recognition of fertilizer materials			
Ability to read and interpret fertilizer labels			
Ability to take a soil sample			
Ability to read a soil test report			
Ability to make good recommendations			
Ability to advise customers			
Ability to sell fertilizer			

(continued on page 87)

What essential understandings, skills, and abilities does the trainee lack or need to develop further?____________________________

____

Does the trainee have the attitudes and appreciations necessary to become a successful employee in the retail fertilizer industry?____

____

If an opening in your firm existed, would you hire him?___________

____

Sources of Suggested Instructional Materials and References

1. Knuti, L. L., et al. *Profitable Soil Management*. Englewood Cliffs, New Jersey. Prentice-Hall, Inc., 1962. Price: $6.16.
2. McVickar, M. H. *Using Commercial Fertilizers*. Second Edition. Danville, Illinois: The Interstate Printers and Publishers, 19-27 N. Jackson, 1961. Price: $3.95.
3. *Be Your Own Corn Doctor*. 4 pages. Price $.03.
4. *Dictionary of Plant Foods*. Philadelphia: Farm Chemicals, Ware Bros. Co., 217 N. Broad Street. 51 pages.
5. *How to Get Good Soil Samples*. Washington, D. C.: American Potash Institute, Inc., 1102 16th Street, N. W. 12 pages. No charge.
6. *How to Take a Soil Sample*. 2 pages. Price $.02.
7. *Methods of Applying Fertilizer*. 20 pages. Price $.10.
8. *Our Land and Its Care*. Fourth Edition. Washington, D. C.: National Plant Food Institute, 1700 K Street N. W., 20006, 1962. 72 pages. Price: $.16.
9. *The Fertilizer Handbook.* Washington, D. C.: National Plant Food Institute, 1700 K Street, N. W., 20006, 1963. Price: $2.
10. *What is Fertilizer?* 14 pages. Price: $.08.

Visual aids

1. How Soil pH Affects Availability of Plant Nutrients. (Poster) National Plant Food Institute, 1700 K Street, Washington, D. C., 20006. Price: $.10.
2. How to Take a Soil Sample. (10 - 35mm. 2" x 2" colored slides) National Plant Food Institute, 1700 K. Street, Washington, D. C., 20006. Price: $2.50.
3. Hunger Signs in Crops. Washington, D. C.: American Society of Agronomy and The National Fertilizer Association, 1963.
4. Lime Means More Money for You. (Poster) National Plant Food Institute, 1700 K Street, Washington, D. C. Price: $.10.
5. Making the Most of a Miracle. (27 minutes, color film) National Plant Food Institute, 1700 K Street, Washington, D. C. Free, return postage.
6. Nutrient - Deficiency Symptoms in Plants. (35mm 2" x 2" colored slides) National Plant Food Institute, 1700 K Street, Washington, D. C., 20006. Price: $.25 each.
7. Soils, Plant Nutrition, and Fertilizers. (64 - 35mm 2" x 2" colored slides) National Plant Food Institute, 1700 K Street, Washington, D. C., 20006. Price: $16.
8. The Big Test. (15 minutes, color) National Plant Food Institute, 1700 K Street, Washington, D. C., 20006. Free, return postage.
9. The Land's Legacy and Promise. (27 minutes, color) National Plant Food Institute, 1700 K Street, Washington, D. C., 20006. Free, return postage.
10. Weather or Not. (22 minutes, color) National Plant Food Institute, 1700 K Street, Washington, D. C., 20006. Free, return postage.
11. What's in the Bag. (17 minutes, color) National Plant Food Institute, 1700 K Street, Washington, D. C., 20006. Free, return postage.
12. Profit in Forage and Pasture. (29 colored slides). National Plant Food Institute, 1700 K Street, Washington, D. C. 20006.

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IN VOCATIONAL AND TECHNICAL EDUCATION
THE OHIO STATE UNIVERSITY
980 KINNEAR ROAD
COLUMBUS, OHIO, 43212

INSTRUCTOR NOTE: As soon as you have completed teaching each module, please record your reaction on this form and return to the above address.

1. Instructor's Name____

2. Name of school____________________________State_______________

3. Course outline used:
_____Agriculture Supply--Sales and Service Occupations
_____Ornamental Horticulture--Service Occupations
_____Agricultural Machinery--Service Occupations

4. Name of module evaluated in this report____________________________

5. To what group (age and/or class description) was this material presented?____
____

6. How many students:
   a) Were enrolled in class (total) ________
   b) Participated in studying this module ________
   c) Participated in a related occupational work experience program while you taught this module ________

7.

Actual time spent teaching module:		Recommended time if you were to teach the module again:
_____hours	Classroom Instruction	_____hours
_____hours	Laboratory Experience	_____hours
_____hours	Occupational Experience (Average time for each student participating)	_____hours
_____hours	Total time	_____hours

(RESPOND TO THE FOLLOWING STATEMENTS WITH A CHECK (✓) ALONG THE LINE TO INDICATE YOUR BEST ESTIMATE.)

VERY APPROPRIATE — NOT APPROPRIATE

8. The suggested time allotments given with this module were: └____.____.____.____.____┘

9. The suggestions for introducing this module were: └____.____.____.____.____┘

10. The suggested competencies to be developed were: └____.____.____.____.____┘

11. For your particular class situation, the level of subject matter content was: └____.____.____.____.____┘

12. The Suggested Teaching-Learning Activities were: └____.____.____.____.____┘

13. The Suggested Instructional Materials and References were: └____.____.____.____.____┘

14. The Suggested Occupational Experiences were: └____.____.____.____.____┘

(OVER)

15. Was the subject matter content sufficiently detailed to enable you to develop the desired degree of competency in the student? Yes_____No_____
Comments:

16. Was the subject matter content directly related to the type of occupational experience the student received? Yes_____No_____
Comments:

17. List any subject matter items which should be added or deleted:

18. List any additional instructional materials and references which you used or think appropriate:

19. List any additional Teaching-Learning Activities which you feel were particularly successful:

20. List any additional Occupational Work Experiences you used or feel appropriate:

21. What do you see as the major strength of this module?

22. What do you see as the major weakness of this module?

23. Other comments concerning this module:

____________________ ____

(Date) (Instructor's Signature)

____

(School Address)